Wine Grape Site Selection in Nova Scotia

Conclusions from the Annapolis Valley Temperature Mapping Project 2004-2008

Background

Nova Scotia's commercial wine industry is relatively young, beginning in the early 1980's, and it has long been known that its cool climate is marginal for wine grape production. Along with this recognition is the appropriate need to identify the best areas within the Province for growing wine grapes, in terms of frost free period (FFP), growing degree day (GDD) accumulation, and minimum winter temperatures. Some basics were known, such as the Annapolis Valley is a warmer area, that sloped sites have better air drainage and therefore longer frost free periods, that if you go inland winter minimums decrease, and that if you go too close to the coast cooling becomes excessive. However, more refined questions remained unanswered – such as "where are the best places within the Annapolis Valley to grow wine grapes?", "what happens as you go east to west in the Annapolis Valley?", "how do other valleys (eg. the Gaspereau, Bear River and LaHave River Valleys) compare to the Annapolis Valley?", "what is the effect of increasing elevation on a slope?", and "what is the effect of slope orientation?". The Annapolis Valley Temperature Mapping Study attempted to answer some of these questions in a five-year study from 2004 to 2008. Soil types were not a part of this analysis.

While investigating the above questions, it is important to have benchmarks that define climatic suitability for wine grape production (Table 1). Most experts agree that a minimum of 900 growing degree days (GDD) above 10 °C are required for wine grape production and ideally above 1300. Additionally, a minimum of 150 frost free days (FFD) is required and ideally up to 180 days. Winter minimums below -26° C are highly undesirable and if they occur more than once every 10 years a site would be considered poor. Sites with winter minimums consistently above -23 °C would be considered most suitable.

Table 1 Climatic limitations to Wine Grape production.

Climate rating	**Degree Days above 10 °C**	**Frost-free period (days)**	**Winter Minimums (°C)**
Most suitable	>1300	180	-21 3 times or less in 10 yrs. Minimum not less than -23.
Good suitability	1100-1300	165	-21 5 times or less in 10 yrs. Minimum not lower than -26.
Fair suitability	900-1100	150	-21 almost every year. -26 or lower only once in 10 yrs.
Poor suitability	<900	130	-23 5 times or more in 10 yrs. -26 3 times or more in 10 yrs.

Methods

Prior to the 2004 growing season, 74 Hobo temperature loggers were deployed on existing vineyards and other areas of interest within the Province. Two to three loggers were deployed on several sloped vineyard sites to elaborate the effect of elevation at a given site. The loggers were placed in radiation shields provided by the supplier, and located 4-feet above the ground facing south so as to minimize shading effects. A temperature reading was collected every 15 minutes from which all climate variables were determined, including frost free period, growing degree day accumulation, and minimum winter temperature. The criteria for determining the frost free period was the number of days between the last spring temperature below 0°C and the first fall temperature below -2°C.ll.

Software designed to manage, analyze, and present the results was developed by the Applied Geomatics Research Group (AGRG)[1], and a selection of the data is presented in Table 2 for the 5-year period of the study. For a detailed examination of all the project data, the reader is directed to visit the website http://agrgims.cogs.nscc.ca/website/AGRGweather/viewer.htm.

Table 2 Average weather data for 30 sites in the Annapolis Valley, Nova Scotia (2004-2008)

Temperature Logger ID	5-Year Average (2004-2008)				
	Elevation (m)	Frost Free Period (Days)	Growing Degree Days (Frost Free Period)	Growing Degree Days (April-Nov)	Minimum Temperature (°C
Armstrong	14	171.5	947.2	975.0	-18.7
Barteaux	21	164.2	867.6	895.4	-20.3
Bennett	43	179.8	1033.8	1042.6	-17.6
Blomidon	17	174.9	971.0	991.2	-19.5
Childs	58	184.7	983.6	1004.0	-20.0
Chipman	17	162.3	948.2	983.6	-20.6
Corkum	29	166.7	1026.6	1055.6	-19.2
Gray	52	149.6	965.0	1012.4	-22.9
Hoganson	49	157.5	951.2	985.2	-23.0
Jost GaspL	24	167.6	977.4	1005.2	-23.6
Jost GaspM	42	177.6	1018.0	1042.6	-21.2
Jost GaspU	60	186.7	1062.2	1086.6	-20.2
McConLb	30	170.6	976.0	1003.2	-21.9
McConLt	47	178.1	988.2	1010.6	-21.9
McConM	44	175.2	989.2	1011.8	-22.1
McConUb	61	180.0	1059.0	1083.8	-21.0
McConUt	77	193.9	1025.6	1040.0	-20.1
Robinson	NA	183.7	840.6	860.0	-15.6
StutzGL	36	171.0	983.8	1010.6	-21.4
StutzGU	64	183.9	1017.2	1033.0	-20.3
StutzGPL	44	188.1	1015.8	1029.8	-19.6

[1] Centre of Geographic Sciences (COGS), Nova Scotia Community College (NSCC), Middleton, Nova Scotia

StutzGPU	49	192.3	1080.4	1096.2	-18.9
StutzWL	48	182.9	974.6	995.0	-20.2
StutzWU	65	184.4	983.2	1003.6	-19.8
VanMeekU	95	184.7	1011.6	1030.8	-19.7
WalshL	104	176.7	1008.8	1032.0	-19.8
WalshU	129	174.3	999.4	1024.4	-20.2
WuhrerL	70	173.7	899.6	920.8	-20.1
WuhrerM	97	184.6	958.8	977.2	-19.4
WuhrerU	106	183.2	964.6	982.6	-19.4
Average	55	176.8	984.3	1007.5	-20.6

Results

1. Comparison to minimum standards

Table 2 presents the 5-year average (2004-2008) data for 30 Annapolis Valley logger sites, many currently in wine grape production. The average frost free period for these sites was 177 days which would place these sites in the “good” to “most” suitable category for wine grape production (see Table 1). Depending on how GDD was calculated, the average degree days above 10 °C was 984 or 1007, both in the middle of the “fair” suitability classification. The average winter minimum for the 30 sites over the 5 years of the project was -20.6 °C which would be in the “most suitable” category for grape growing; however, some individual sites averaged below -23 °C and most had at least one year (in 5) when their minimum winter temperature was below -23 °C (data not shown). As such most sites do not qualify as “most suitable” for this variable and would in fact have been more appropriately categorized as having “fair” to “good” suitability. Considering all the variables collectively, climatic suitability for grape growing in the Annapolis Valley would be most appropriately described as having fair to good suitability, using the criterion presented in Table 1.

It would be easy to extrapolate from this analysis that grape growing in Nova Scotia itself could be described as having fair to good suitability; however, one must remember that the data above is from the Annapolis Valley which is considered the most desirable area in the Province for growing grapes. When we compare Valley sites to other areas in the Province and to other established viticultural regions in the country, we obtain a much better perspective on the marginality of the Province overall for grape growing.

Table 3 presents long-term weather normals (1971-2000) for several Valley sites, as well as other areas of the Province, and for the two major viticultural regions in the country – the Niagara and Okanagon Valleys respectively. When we examine these normals, particularly those for GDD, we see that most areas of the Province are well below the minimum normals for growing grapes successfully (see Table 1) and that even best sites in Nova Scotia have GDD’s well below those of the Okanagan and Niagara Valleys. Other climate variables such as 'average temperature' and 'average number of days below -20 °C' further support this observation.

Table 3 Comparison of weather normals from selected sites in Nova Scotia to other Canadian viticultural regions in Canada (1971-2000)[2]

Location	Precipitation (mm/year)	Average temperature (°C)	Average # days below -20 C	Growing Degree Days (Base 10 °C for 1971-2000)
Niagara ON	944	9.0	1.1	1471
Okanagan BC	333	9.2	0.2	1181
Windsor Martock, NS	1308	7.4	3.6	1061
Kentville NS	1211	6.9	3.4	1006
Annapolis Royal, NS	1209	7.1	1.4	889
Yarmouth, NS	1274	7.0	0.1	711
Bridgewater, NS	1523	6.8	7.3	943
Middle Musquodoboit, NS	1370	6.2	10.6	863
Truro, NS	1202	5.8	10.5	839
Parrsboro, NS	1282	5.8	8.2	770
Nappan, NS	1175	5.8	12.2	863
Pugwash, NS	1052	6.6	8.3	1029
Baddeck, NS	1501	6.2	4.1	829
Sydney, NS	1505	5.5	3.4	749
Cheticamp, NS	1391	6.2	3	849
Louisbourg, NS	1599	5.5	1.9	628

2. North Mountain versus South Mountain

There was only one north-facing (South Mountain) site where data was collected for the 5 year duration of the temperature mapping project and this was located in Rockland south of Berwick and identified as the 'Walsh' site. This was a high elevation site where essentially the lower logger located at 104 meters gave the most favourable site data (Table 4). The most appropriate south-facing (North Mountain) sites for comparison would be the middle (97 m) and upper (106 m) loggers at the 'Wuhrer' site in North Kingston and the upper logger (95 m) at the 'Van Meekeren' site in Lakeville. Interestingly, the three North Mountain loggers had frost free periods approximately a week longer than the South Mountain site, perhaps due to the greater influence of the Bay of Fundy on the closer North Mountain sites. However, the South Mountain site was warmer than the westerly Wuhrer site and no different from the easterly Van Meekeren site. Moreover, the average winter minimums for the four loggers were essentially the same. This is striking evidence that north facing South Mountain sites have essentially the

[2] Environment Canada. Canadian Climate Normals 1971-2000: http://climate.weatheroffice.gc.ca/climate_normals/index_e.html

same climate suitability for wine grape production as the generally preferred North Mountain sites. Inferior light quality at South Mountain sites is a concern; however, the slopes in question are generally below 10% and as such not significantly affected by this variable. Recent vineyards established on the north-facing side of the South Mountain appear to be performing well and add further support for the viability of vineyard development on the north-facing slopes of South Mountain.

Table 4 Average data for selected sites in Annapolis Valley temperature mapping project (2004-2008)					
Logger ID	**Elevation (m)**	**5-Year Average (2004-2008)**			
		Frost Free Period (Days)	**Total Growing Degree Days (FFP)**	**Total Growing Degree Days (April-Nov)**	**Min Temp (°C)**
Walsh (lower)	104	176.7	1008.8	1032.0	-19.8
Wuhrer (middle)	97	184.6	958.8	977.2	-19.4
Wuhrer (upper)	106	183.2	964.6	982.6	-19.4
Van Meekeren (upper)	95	184.7	1011.6	1030.8	-19.7

3 Effect of elevation on a site

Prior to the study there was a feeling among more experienced growers that as you climb the slope in a vineyard there is an incremental increase in temperature and GDD. If true this had important implications for variety location and vineyard lay-out. To answer this question, 2-3 loggers were located at different elevations at 9 separate vineyards. A failed logger at one site reduced the analysis to eight sites but for 7 of these the effect of increasing elevation was to increase the 'frost free period' and GDD accumulation. Similarly, average winter minimums were milder (5 sites) or unchanged (2 sites) as elevation increased at these seven sites. The one site that did not follow these trends was the 'Walsh' site which is singularly unique in that it is a north-facing site on the South Mountain and at higher elevation than all the other sites. Is this site behaving differently because it is "north-facing" with poorer light quality, because of its greater distance from the Bay of Fundy, or is there another explanation?

Experts agree that as elevation increases there comes a point where the increasing heat trend reverses and it is very possible the high elevation 'Walsh' site spans this juncture. The latter explanation is supported by the observation at the 'Wuhrer' site of essentially no data change from the mid-slope logger located at 97 meters (above sea level) and the upper slope logger at 106 meters. It is noteworthy that the logger elevations at the Walsh site are 104 and 129 meters respectively. This suggests that the "sweet spot" in the Annapolis Valley above which no further temperature gain can be expected is around 100 meters above sea level. Up to this point we see gains in frost free period and GDD, accompanied by milder winter minimums. The implications of this theory, if true, would be to site late maturing, more winter sensitive varieties on the upper slopes of vineyard sites to an elevation maximum of 100 m.

4. East to west in the Annapolis Valley

The data for the three Valley sites in Table 3 (Windsor Martock, Kentville, and Annapolis Royal) would suggest that there are less GDD's accumulated as one goes from east to west. It would also suggest that it becomes marginally milder during winter as one goes east to west, as evidenced by the fewer days below -20 °C in an average year. However, when we look at data from selected north and south mountain sites in the climate project the picture is less clear (Table 5).

Table 5 Average weather data for selected North Mountain and South Mountain sites in the Annapolis Valley Temperature Mapping Project

Logger ID	**Elevation (m)**	**Frost Free Period (Days)**	**Growing Degree Days (FFP)**	**Growing Degree Days (April-Nov)**	**Wint Min. Temp (°C)**
A. North Mountain sites presented east to west					
	3-Year Average (2006-2008)				
Stutz (Woodside upper)	65	185.1	1004.7	1035.7	-18.4
Van Meekeren (Lakeville upper)	95	183.1	1035.3	1065.0	-18.2
Wuhrer (North Kingston lower)	70	173.5	997.0	1031.7	-19.0
Wuhrer (North Kingston mid-slope)	97	185.1	978.0	1006.0	-18.2
Chisholm (North Middleton)	95	178.8	999.3	1029.7	-17.8
Bent (Clarence)	74	169.9	944.7	973.7	-19.3
Stacey (North Bridgetown)	239	195.7	972.7	992.0	-19.0
Armstrong (Granville Beach)	14	167.3	994.3	1036.7	-17.3
B. South Mountain sites presented east to west					
		4-Year Average (2005-2008)			
Corkum (Falmouth)	29	169.2	1054.8	1091.0	-20.7
Ewert (Gasperaux upper)	40	183.0	1033.5	1061.8	-19.7[a]
Walsh (Rockland lower)	104	179.5	1032.8	1061.8	-18.9
Gray (South Berwick)	52	155.2	992.8	1052.0	-22.5
Wentzell (Nictaux)	33	155.3	985.8	1042.0	-22.5
Mahar (Paradise		155.6	941.5	997.3	-21.7

lower)	34				
Barteaux (Mochelle)	21	169.8	938.0	972.8	-19.8
Hawes (Bear River upper)	50	162.2	989.0	1029.5	-20.8

[a] Winter minimum is calculated from 2006-2008 data; data from 2005 is missing

Starting with the North Mountain sites, if we compensate for elevation effects the data suggests that GDD decreases going east to west until roughly the mid-Valley area and then increases again on the western end of the North Mountain. This trend is subtle and no doubt complicated by microclimate effects of a given site. Examining the frost free period and winter minimum temperature data, no obvious trends are evident.

For the South Mountain analysis the reader should recognize that this feature is much less uniform than North Mountain and as such more subject to interaction with other geographic influences (eg. surrounding ridges, tidal rivers, sub-valley's, etc) and thus misinterpretation. Having said this, the four year data presented in Table 5 suggests a similar pattern to the north mountain analysis where GDD slowly decreases from east to west, but in this case only shows an increase at the final logger location in Bear River, perhaps aided by the higher elevation and unique microclimate of this site. Again like the North Mountain analysis, there are no obvious trends describing the frost free and winter minimum data for the south mountain sites.

5. Comparison of other production areas to the Annapolis valley

The Annapolis Valley is considered the most desirable area in Nova Scotia for growing wine grapes but several other areas have proven successful and it is interesting to compare the data from these areas (Table 6). Surprisingly, of the four areas from which data are presented Malagash had marginally the longest frost free period and GDD accumulation, followed closely by the Annapolis Valley. Unfortunately, Malagash also had the lowest winter minimum average for the five year period whereas the Annapolis Valley average was the mildest for this variable. Overall, this data suggests that other areas compare well to the Annapolis Valley and that there may well be other favourable regions in the Province for wine grape production.

Table 6 Comparison of Annapolis Valley Sites to other wine grape production areas in Nova Scotia

Logger ID	**5-Year Average (2004-2008)**			
	Frost Free Period (Days)	**Total Growing Degree Days (FFP)**	**Total Growing Degree Days (April-Nov)**	**Min Temp (°C)**
Annapolis Valley site average (30 logger sites)	176.8	984.3	1007.5	-20.6
Malagash (1 site)	178.8	994.4	1014.8	-23.3
LaHave Valley site average (4 sites)	165.8	968.6	989.3	-22.4

Bear River site average (2 sites)	159.2	936.4	969.2	-21.1

6. Annual variation in data.

Annual variation in weather must be considered when growing wine grapes in cool climates. Figures 1-3 show the annual variation of the weather data from 36 sites in the project over the 5-year period of the project. Examining the frost free period data, one sees a range from 163 days to 185, illustrating that years may range from fair suitability to most suitable (see Table 1). Similarly, the range for GDD's accumulated during the frost free period (Fig.2) is from a low of 871 in 2004 to a high of 1044 in 2006. The average GDD was 981 for the 5-year period showing that annual variation from the average was as much as 11%. 981 GDD's is well above the "900" threshold for growing wine grapes but we see that with a 11% decrease in heat we have dropped into the "poor" suitability category for one year of the 5-year study. This becomes even more important when assessing individual sites that may have marginal GDD averages (such as 900). In the latter cases, we must recognize that 50% of years are actually going to have "poor" suitability for grape growing.

Figure 3 shows the annual variation for winter minimum temperature in the 5-year study. The range for this variable was from -17.5 °C in 2006 to -22.9 ° in 2004 with an average value of -20.6 °C for the period. This variation is as much as 15% from the average and again suggests colder sites with winter minimum averages of -23 °C or lower would have years with winter minimums below -26, the latter being an important threshold for damage. Collectively, this analysis demonstrates the risk in relying only on long-term average data for a site. One must also have a grasp of the year-to-year variability of a site to make a reliable determination of suitability.

Fig.1 Annual average Frost Free Period (days) for 36 sites in the Annapolis Valley Temperature Mapping Project (2004-2008)

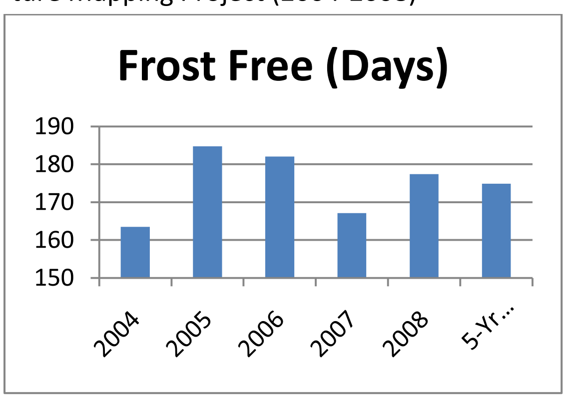


Fig.2 Annual average Growing Degree Days for 36 sites in the Annapolis Valley Temperature Mapping Project (2004-2008)

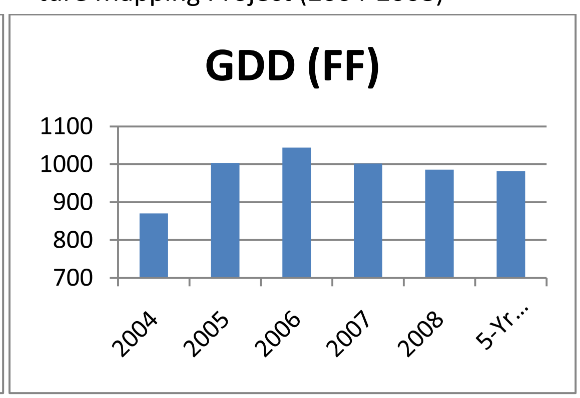
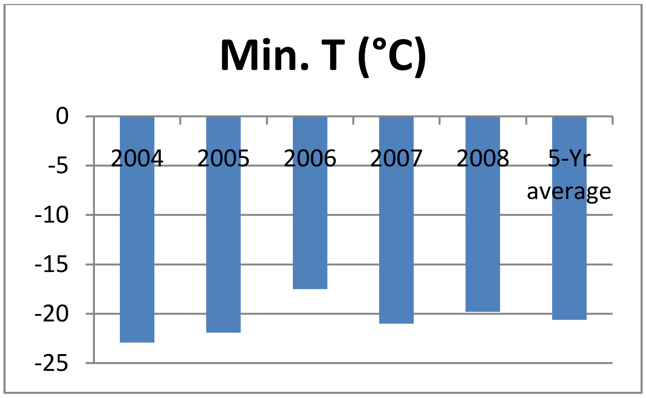


Fig.3 Annual average Winter Minimum Temperature (°C) for 36 sites in the Annapolis Valley Temperature Mapping Project (2004-2008)



Conclusions

The Annapolis Valley Temperature Mapping project illustrated a number of important findings. Firstly, it verified that the Annapolis Valley is one of the better areas within Nova Scotia for wine grape production and that, by comparison, most areas of the Province are not suitable for the production of this crop. Also, in comparison to the two largest viticultural regions in Canada, the Niagara and Okanagon Valleys, the Annapolis Valley would be best described as having fair to good suitability for wine grape production. This is largely because of its modest degree day accumulations and relatively low winter minimums compared to these other regions.

Although most “outside Valley” areas would be unsuitable for wine grape production, weather data from several areas, including Bear River, LaHave River region, and the Northumberland Shore area, compared favourably to that of the Annapolis Valley sites. In conjunction with this, these areas all have wineries and all are demonstrating themselves to be interesting and successful appellations. More data would be desirable to further elaborate on these areas, as well as others as yet unidentified.

The project also provided data that supported the premise that “north-facing” South Mountain sites in the Annapolis Valley can be suitable for wine grape production, in addition to the accepted “south-facing” North Mountain sites. This adds tremendously to the suitable land base for wine grape production and several growers have already taken advantage of this opportunity with new vineyards started on several South Mountain sites.

Experienced grape growers have long believed that the upper areas of their vineyards were hotter and the project clearly validated this conviction. GDD’s were seen to increase gradually with increasing elevation on a site, along with frost free period and milder winter minimums. These effects appear to be valid up to an elevation of 100m, both on North and South Mountain sites. Growers are taking great advantage of this information by planting their later maturing and/or more winter sensitive varieties on the upper slopes of their sites.

There have been indications that the eastern end of the Annapolis Valley is climatically more suitable for wine grape production than the western end, at least as far as GDD's are concerned; however, this project showed that this notion is not so straight forward and that strong meso- and microclimate influences may override expected trends. While GDD's tended to decrease as one moved from east to west in the study, the effect seemed to bottom out in the mid-Valley area and increase thereafter. Areas on the western end of the Valley, including Paradise, Granville Beach, and Bear River had surprising high GDD's and it is wondered if these are aberrations caused by unique topography in these areas. Regardless, there does appear to be very acceptable areas for wine grape production on the western end of the Annapolis Valley. Interestingly, no obvious trends in frost free period or winter minimum temperature were observed in the data.

Although most project data was collected from the Annapolis Valley, some was collected from areas of interest outside the Valley proper and these were compared in the analysis. Interestingly, Malagash (on the Northumberland shore) had a higher GDD accumulation than the averaged Annapolis Valley data, and though its winter minimum was the lowest among the areas compared, this region is deserving of greater exploration and development for wine grape production. Similarly, the data from the five LaHave River area sites and a Bear River site also compared favourably to that of the Annapolis Valley, supporting them as viable viticultural areas.

Finally, the average data expressed over the five years of the study demonstrated significant annual variability in the data. The implications of this are that marginal sites will have years with "poor" suitability numbers and may not be viable production sites. It also illustrates the risk in relying too heavily on long-term climate normals or average weather data for site assessment and emphasizes the need for site specific data and assessment of the year-to-year variability of a site.

Nova Scotia is truly a cool climate viticulture region and, although this brings great opportunity in the form of its ability to make excellent wines, it also introduces challenging climate risks. To be economically successful, one must minimize these risks by identifying only best sites for production. The Annapolis Valley Temperature Mapping Project is an attempt to do so but is truly only the beginning of this process. Much has been learned but further elaboration of the study area and other promising areas of the Province are still needed to allow the full developmental potential of this exciting crop.

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