NYWGF RESEARCH - FINAL REPORT

Funding for fiscal year: 2023-2024

SECTION 1:

Project title: Cold hardiness monitoring and microclimate optimization of grapevines in New York 2023-2024.

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New Research ☒ **Continued Research** ☒ (CHECK APPROPRIATE BOX)

Amount Funded $ 39,794.00

SECTION 2:

Project Summary Impact Statement:

Growing grapes in New York is a delicate balance between cultivar, environment, and consumer demand. One of the leading limiting factors is our winter climate and the vine's ability to survive acute cold events. This project continued the dormant bud cold hardiness monitoring of grapevines in the Finger Lakes, Lake Erie, and Hudson Valley regions. Cold hardiness of multiple cultivars was evaluated throughout the winter using differential thermal analysis. This data was uploaded to the Cornell grapevine bud cold hardiness website and made available to growers in real time. In addition to field measures, the project website provided cold hardiness estimates at hundreds of weather station locations in New York, and thousands of sites across the Northeastern US. In addition, we expanded our assessment of vine winter physiology have begun to develop the data needed to model fruit growth and ripening during the growing season as it is affected by microclimate variation in the Finger Lakes and Lake Erie Region. Eighteen different Riesling vineyards and 15 Concord vineyards were monitored for cold hardiness biweekly during the winter and compared with local climate data collection. During the growing seasons, these microclimate locations were also monitored for

differences in phenology, berry set, and berry ripening metrics.

Objectives: The objectives of this study were to conduct cold hardiness assays for multiple cultivars and in multiple locations, to determine the variability in cold hardiness between vineyards for Concord and Riesling, and to provide updated field cold hardiness and cold hardiness predictions for the New York grapevine industry.

1: Monitor the cold hardiness of *vinifera* and hybrid cultivars over the winter season of 2023-2024 using differential thermal analysis of dormant bud tissue from the Finger Lakes and Lake Erie growing regions (Continued project).

2: Continue our winter microclimate study, which tracks the local variation in cold hardiness and budbreak phenology in lakeside microclimates in the Finger Lakes and Lake Erie (Continued project).

3: Expand our microclimate study into the growing season to collect data on changes in soil water content, vine water use efficiency, fruit growth and ripening to generate the data needed to develop climate suitability models (New concept).

4: Process the data and provide summary cold hardiness and budbreak data to growers and producers through extension presentations, Appellation Cornell, and the newly developed Cornell Bud Hardiness application.

Materials & Methods:

Plant Material: Throughout the 2023-2024 season, multiple grapevine cultivars were tracked for changes in cold hardiness by the project team. In Geneva, NY, twelve cultivars were assayed weekly, beginning October 17, 2023, through March 25, 2024. Starting on December 6, 2023, through March 13, 2024, five cultivars were sampled every two weeks from various Finger Lakes vineyards. In Portland, NY, eighteen cultivars were assayed weekly, beginning November 27, 2023, through March 27, 2024. Plant collection for all sites and cultivars were the same. At each location, cuttings of dormant cane and bud tissue were collected in the field, bundled, and transported to Cornell Agritech in Geneva, NY, the CLERL laboratory in Portland, NY, or the Hudson Valley Lab in Highland, NY. At the cold hardiness labs, dormant buds were excised from canes and placed onto Peltier plates seated into sample trays. After all samples were processed for a given collection date, the sample trays were placed in programmable freezers and a controlled freezing assay was conducted.

Differential Thermal Analysis: Differential thermal analysis (DTA) is a standard method for determining the temperature that results in a lethal freezing event inside the dormant grapevine buds. To conduct these tests, the programmable freezers were cooled to 32°F/0°C and held for two hours to synchronize temperatures across all sample trays and buds. Then temperatures are decreased at -°7.2F/-4°C per hour to a minimum temperature of -40°F/-40°C. Cold hardiness is measured during these assays by monitoring the voltage produced on Peltier plates in the sample plates. When water within the dormant bud freezes, the state transition from liquid water to ice releases a small amount of heat. This heat causes an alteration in the voltage produced across the surface of the Peltier plate, and we record this change as the temperature where lethal freezing has occurred. Following these cold hardiness freezer experiments, we manually record the voltage peaks caused by lethal freezing, and report that information as the field temperature that is expected to cause lethal bud damage in vineyards. DTA data were collected in this project for the cultivar monitoring (Obj. 1) and microclimate (Obj. 2) portions of this study.

Microclimate tracking: In addition to the weekly and biweekly monitoring project (Obj. 1), we conducted two microclimate studies. The first of the two studies were conducted in the Finger Lakes region and targeted eighteen different Riesling vineyards. Vineyards were selected to create six different transects encircling the southern end of Seneca Lake. Each transect included vineyards with varying distance from the lakeshore to measure any potential impacts of microclimate warming associated with elevation or proximity to the Lake. The second of the two studies were conducted in the Portland, NY region and targeted fifteen different Concord vineyards. The general concept was similar, with five transects extending from the shoreline of Lake Erie up the escarpment. Ultimately, the distribution of vineyards in this region resulted in two clusters of vineyard sites. Seven sites were located to the southwest of Portland, NY and eight sites were located to the northeast. The distribution resulted in a total of four lakeshore, eight middle, and three escarpment sites. At each vineyard location, two Bluetooth sensors (SensorPush) were attached to vineyard trellis posts. Each sensor records temperature, humidity, and barometric pressure in one-minute increments, as well as derived measures of vapor pressure deficit and dewpoint. To correlate variation in microclimate conditions with variation in vine cold hardiness, dormant bud tissue was collected from all sensor sites every two weeks and examined with DTA methods to determine cold hardiness. Riesling sites were sampled beginning on November 11, 2023, and ending on March 26, 2024. Concord sites were sampled beginning on December 13, 2023 and ending on March 18, 2024.

Microclimate impacts on berry ripening (Obj 3): To continue our analysis of microclimate effects on grapevine we sampled developing berries at biweekly timepoints throughout the growing season. From each of the microclimate sites, 100 berries were sampled at roughly biweekly timepoints. Berry collection was stratified, collecting 2 berries per cluster, randomly sampling from vines within the vineyard. Sample collection started on July 25, 2024 and concluded on September 29, 2024 in the FLX region. Sample collection started on July 27, 2024 and concluded on September 21, 2024 in the WNY region. For FLX samples, each individual berry was weighed. Berries from each collection were arranged on a gridded platform and imaged with an iphone. Diameter measures for each berry was measured using ImageJ software. For WNY samples, berries were weighed and measured as 20 berry subsamples. Berry density values were computed from weight and height measures, assuming a spherical shape for each berry. Berry brix and TA was measured using 20 berry subsamples. Brix was measured with digital refractometers and TA was measured using a Mantech MT30 autosampler robot and acidity module in the Londo lab.

Results/Outcomes/Next Steps:

Objective 1: During the 2023-2024 winter, twelve cultivars were monitored for cold hardiness in the Geneva dataset, fourteen cultivars in the Portland dataset, five cultivars in the Hudson Valley, and 5 cultivars in the greater Finger Lakes region dataset (Table 1). The winter conditions were extremely mild, and there were no acute cold events that surpassed the cold hardiness levels measured across the state (Figure 1, Figure 2). Maximum cold hardiness values for Geneva and Portland was observed for most cultivars in mid-January (Table 2). The results of our monitoring program were updated throughout winter on a weekly basis at the Cornell Grapevine Cold Hardiness website (https://grapecoldhardiness.shinyapps.io/grape_freezing_tolerance/), providing growers with a view into the potential for freeze damage in their vines.

Objective 2: The microclimate study is in its second year of data collection and patterns of variation seen between sites was seen in the repeated sample. The winter conditions during the 2023-2024

season were quite mild, and as a result the maximal cold hardiness observed across sites was lower. Cold hardiness is a dynamic trait and comparisons at any single collection time point is quite variable. For 2022-2023, Riesling microclimate sites ranged by up to 7 degrees Fahrenheit between the least and most cold hardy locations. In 2023-2024, this variation increased to 8 degrees Fahrenheit (Figure 3, Table 3). This level of variation demonstrates the very large role of site on maximum cold hardiness. There was not a consistent pattern of maximum cold hardiness as determined by distance from Seneca Lake, nor when broadly comparing East vs. West sides of the lake.
Concord microclimate sites were similarly variable in both years of the study. Differences between sites were 7 degrees Fahrenheit between least and most cold hardy locations in 2022-2023. This difference was 6.5 degrees Fahrenheit in 2023-2024. There was a slight trend with Lakeside sites being less cold hardy than Mid and Escarpment sites, in line with expectations for a buffering effect of Lake Erie. This trend was observed in both years of the study.

In conclusion, there are considerable differences in microclimate cold hardiness in both Finger Lakes Riesling and Western New York Concord vineyards and these differences are only partially explained by our current understanding of lake effect impacts. We plan to repeat the study for at least one additional winter to determine if these patterns are repeatable across years. The data collected here will also be used to fine tune cold hardiness prediction models that have been developed in the PI's research program.

Objective 3: Microclimate effects on berry ripening and quality. Berry subsamples were collected from all microclimate sites for both Riesling and Concord in 2023. Six different samplings were conducted starting prior to veraison and concluding at commercial harvest in each region. Riesling berries were sampled starting July 7th and concluded on September 29th while Concord berries were sampled August 9th and concluded on September 21st. Extensive variation in berry size, weigh, brix, TA, and sugar/acid ratio was apparent between microclimate locations. When sampling data was corrected as heat units (GDD), clear variation between sites was apparent (Figure 5). Malic acid concentrations in both Riesling and Concord followed tight curves of degradation with slight variation by microclimate site. Brix was far more variable by site, with much higher development in Riesling than Concord, and within Riesling sites, enhanced for the transect FLX3. This site is on the Southeast corner of Seneca lake and suggests that the warmer microclimate here enhances sugar development. As a result of the higher sugars, the sugar/acid ratio of these sites deviated from the expected linear relationship seen for post-veraison fruit. For Concord, Lakeside microclimates lagged in sugar development and in Malic acid degradation, likely a result of the cooling affect of the Lake Erie microclimate. As a result of greater heat accumulation, sites on the escarpment (3_1 and 3_2) have the highest sugar/acid ratio.

Technology Transfer Plan: The primary method of transferring the results of this study is the goal of Objective 4, sharing of results through extension presentations, Appellation Cornell and through the Cornell Grapevine Cold Hardiness website. During the 2023-2024 season, the results of our monitoring program have been shared through two episodes of the "Between the vines" podcast, Cornell Cooperative Extension newsletters, crop updates, and in person extension presentations. The primary transfer of our results has been through the Cornell Cold Hardiness website (https://cals.cornell.edu/viticulture-enology/research-extension/bud-hardiness-data) which now links to an interactive application running through the R shiny interface (https://grapecoldhardiness.shinyapps.io/grape_freezing_tolerance/). The interface allows for user interaction with a number of different parameters including selection of weather station/location and cultivar. For sites that are tied to the Geneva and Portland, NY monitoring programs (Obj. 1), users can see up to date cold hardiness data for the temperatures expected to cause 10, 50, and 90% of bud damage (LT10, LT50, LT90). Though not supported through this study, the Londo lab has also developed two cold hardiness prediction models using past cold hardiness data collection supported by NYWGF (2009-2021). These cold hardiness models are posted on the new web interface, allowing growers to compare the field collected data with model predictions. For weather station sites that are not located in Geneva or Portland, these models allow the user to see what the predicted cold hardiness is for sixteen different cultivars.

Next Steps: The data shared here is part of a series of multiyear studies. As such, the final conclusions from data analysis are not yet available. Our plan is to complete a third year of sampling for the microclimate sites during the winter of 2024-2025. It is our intention to make this the final year of sampling, as clear patterns of cold hardiness variation have been seen in the two previous years of study. We plan to produce both an extension oriented and peer review journal format publication from this work. For the berry growth and ripening work, we plan to complete at least a second year of sampling, and hopefully a third or fourth, depending on funding and results. The preliminary results shown here demonstrate substantial variation in ripening processes across the microclimate locations for both cultivars. Our ongoing work expands this effort to examine many more cultivars in both the FLX and WNY regions with the aim of developing crop estimation tools and berry ripening models for vinifera, labruscana, and hybrid cultivars. The results presented here are but a brief summary of the data available. If the reader is interested in a particular aspect of the research, please reach out to Dr. Londo for more information.

Acknowlegements: It is critical to acknowledge the important work of technical staff associated with our research programs as well as the vineyard growers who enable this work. We would like to acknowledge Hanna Martens, Phil Simmons, Suzanne Choate, and Sophie Bauer from the Londo program, Don Caldwell from the Walter-Peterson program, and Kim Knappenberger from the Russo program. We also want to thank the following vineyards: Ravines vineyard, Prejean vineyard, New Vines vineyard, Miles vineyard, Anthony Road vineyard, Glenora vineyard, Tabora vineyard, Lakewood vineyard, Sawmill Creek vineyard, Hillick and Hobbs vineyard, Boundary Breaks vineyard, Dalrymple farms, Boom Point, Rooster Hill, and growers: Young, Gage, Hicks, Tones, Ortolano, Bell, Jordan, Betts, Mobilia, Cross, Rak, Sprague, Sprague Sr., Schneider, Szumigala, and McGuinn.

Attachments:

Table 1: List of cultivars monitored during the 2023-2024 winter season by the project PI's.

	Geneva, NY	Finger Lakes Region	Portland, NY	Hudson Valley, NY
Aravelle	x			
Aurore			x	
Cabernet Franc	x	x	x	x
Cabernet Sauvignon	x			
Cayuga White	x	x		
Chardonnay	x			x
Concord	x	x	x	
Delaware			x	
Elvira			x	
Gewurztraminer	x		x	
Ives			x	
Lemberger	x	x		x
Marquette	x			
Merlot	x			x
Niagara			x	
Pinot gris			x	
Pinot noir				x
Riesling	x	x	x	
Sauvignon blanc	x			
Seyval			x	
Traminette			x	
Vignoles			x	
Vincent			x	

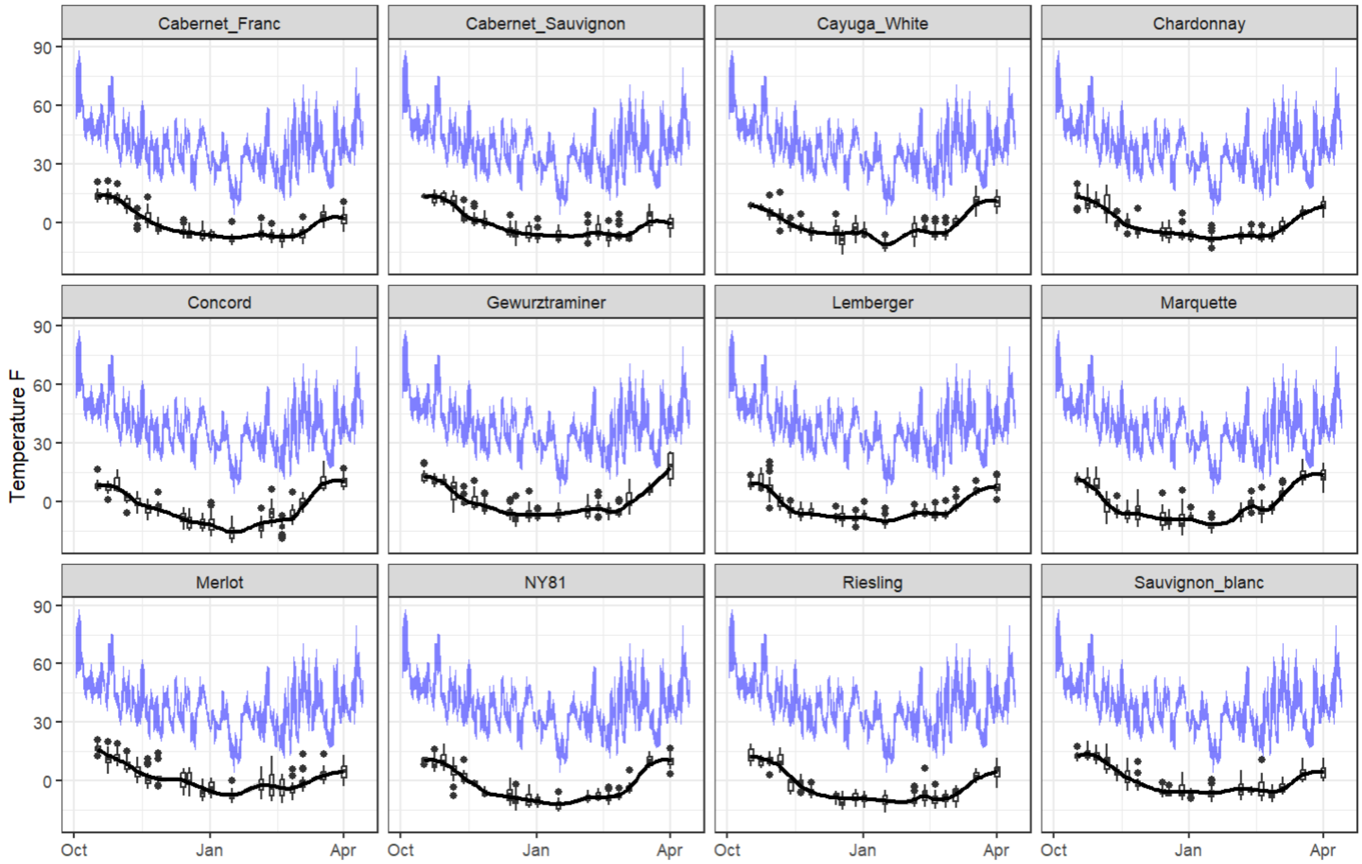

Figure 1: Cold hardiness curves for twelve genotypes sampled in the Figure Lakes region. Weekly data shown as boxplots. Black line indicates the LT50, or temperature which was observed to kill 50% of the sampled buds at each collection time point.

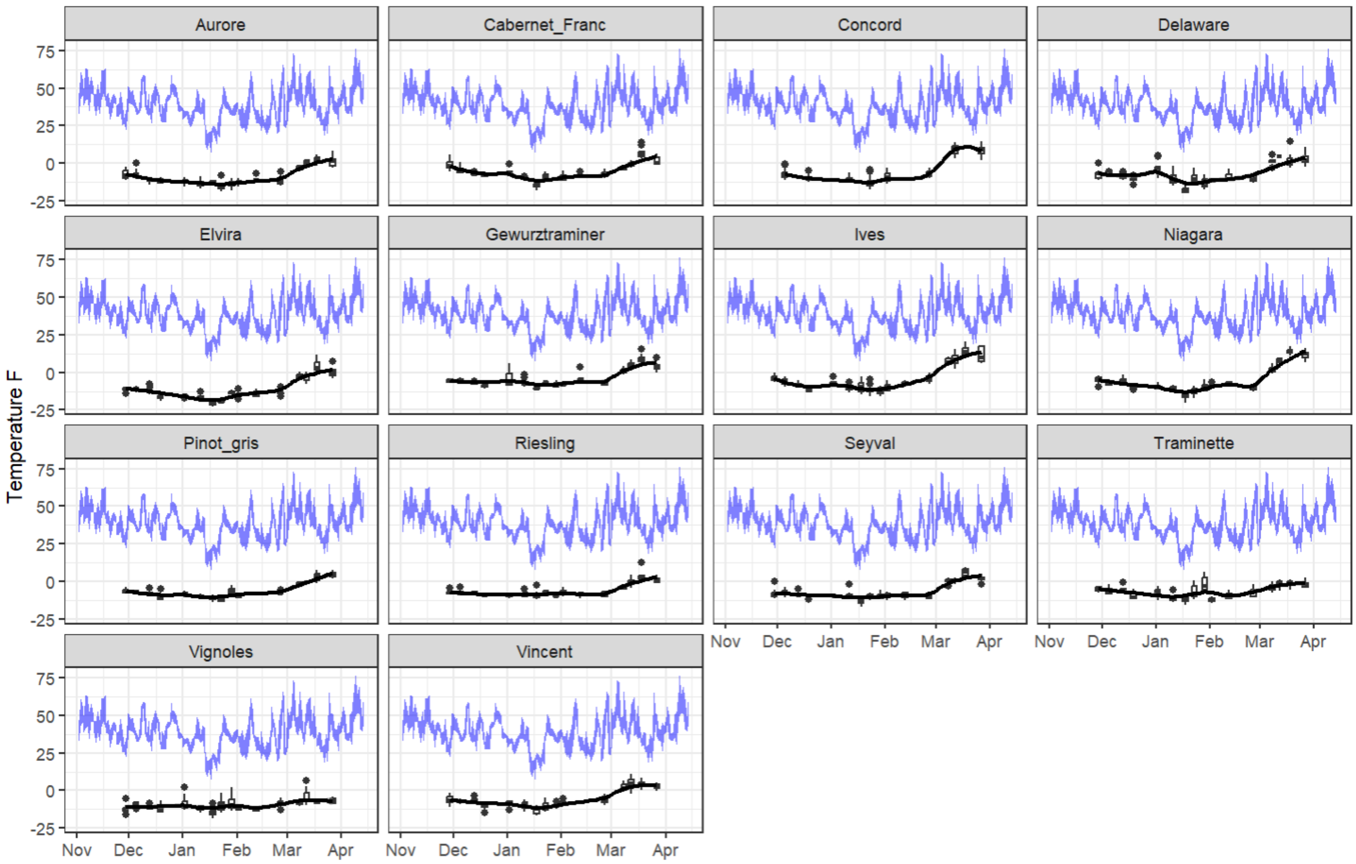

Figure 2: Cold hardiness curves for 14 genotypes sampled in the Portland NY region. Weekly data shown as boxplots. Black line indicates the LT50, or temperature which was observed to kill 50% of the sampled buds at each collection time point.

Table 2. Date of maximum cold hardiness measured (°F) from the cultivars monitored in the Geneva and Portland cold hardiness programs. LT10/50/90 measures indicate the temperature expected to kill 10%, 50%, and 90% of primary buds.

Location	Cultivar	Date	LT10	LT50	LT90
Geneva	Aravelle	1/16/2024	-9.76	-12.64	-15.34
Geneva	Cabernet Franc	1/16/2024	-6.7	-9.04	-11.38
Geneva	Cabernet Sauvignon	2/19/2024	-4.18	-7.96	-11.74
Geneva	Cayuga White	1/16/2024	-9.04	-12.1	-14.98
Geneva	Chardonnay	1/16/2024	-5.44	-9.04	-12.46
Geneva	Concord	1/16/2024	-12.28	-16.42	-20.56
Geneva	Gewurztraminer	12/18/2023	-6.88	-9.4	-11.92
Geneva	Lemberger	1/16/2024	-8.32	-11.02	-13.72
Geneva	Marquette	1/16/2024	-9.4	-12.64	-16.06
Geneva	Merlot	1/16/2024	-5.08	-8.14	-11.38
Geneva	Riesling	12/18/2023	-7.42	-11.2	-14.8
Geneva	Sauvignon blanc	2/26/2024	-4.36	-7.42	-10.48
Portland	Cabernet Franc	1/18/2024	-11.74	-14.62	-17.5
Portland	Delaware	1/18/2024	-15.88	-18.04	-20.2
Portland	Elvira	1/18/2024	-18.94	-20.38	-21.82
Portland	Gewurztraminer	1/18/2024	-10.3	-10.66	-11.02
Portland	Niagara	1/18/2024	-12.28	-15.7	-18.94
Portland	Riesling	1/18/2024	-8.14	-9.94	-11.74
Portland	Seyval	1/18/2024	-11.2	-13	-14.8
Portland	Traminette	1/18/2024	-10.12	-12.46	-14.8
Portland	Vignoles	1/18/2024	-10.48	-14.62	-18.76
Portland	Vincent	1/18/2024	-10.3	-13.18	-15.88
Portland	Aurora	1/23/2024	-13.9	-16.06	-18.22
Portland	Concord	1/23/2024	-9.76	-13.72	-17.68
Portland	Pinot gris	1/23/2024	-9.94	-11.74	-13.72
Portland	Ives	1/29/2024	-9.76	-12.46	-14.98

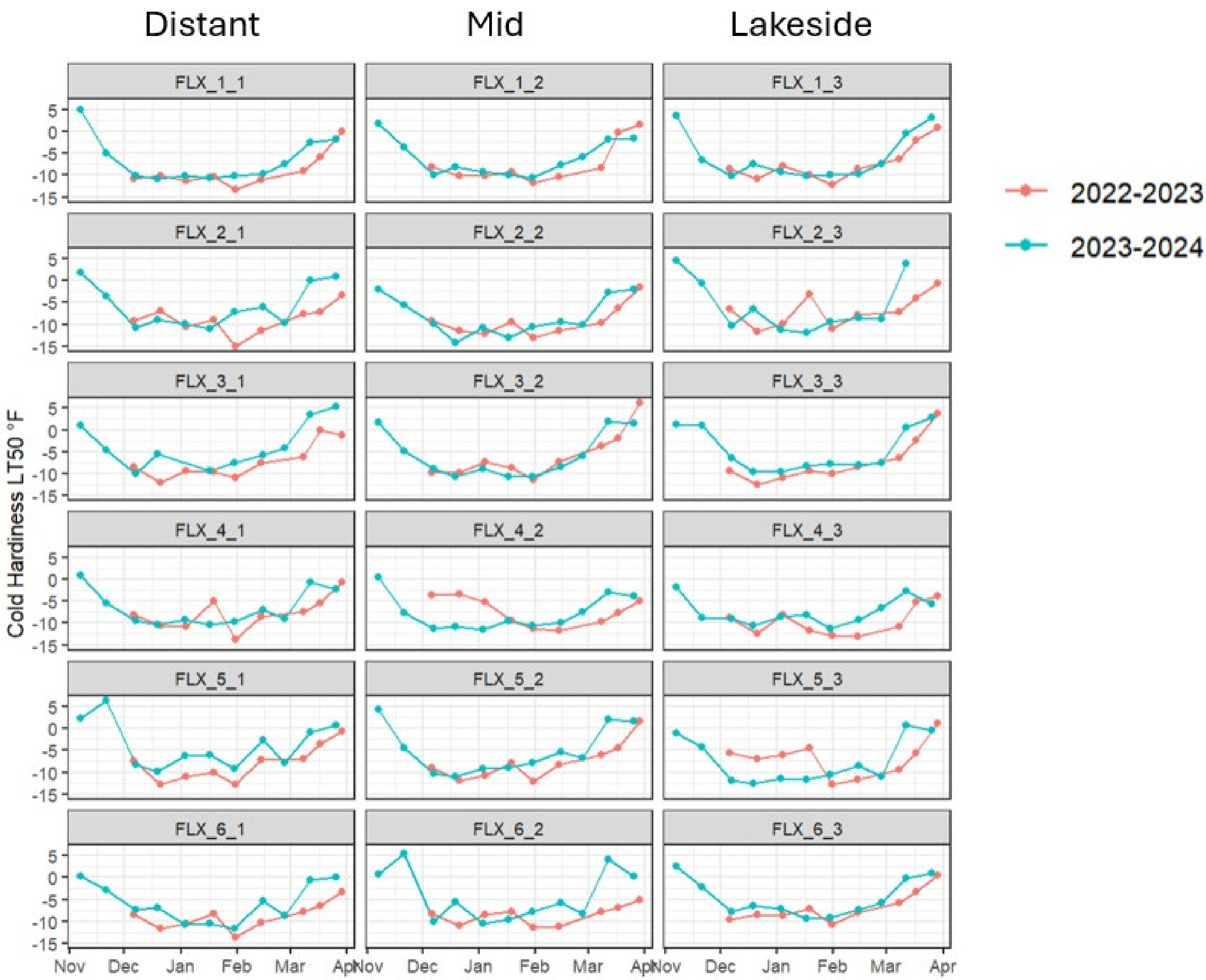

Figure 3. Cold hardiness curves showing LT50 values for Riesling samples collected in the Finger Lakes region. Milder conditions during 2023-2024 tended to result in less cold hardiness at each site relative to the previous year's sampling. Eastern sites are FLX 1, 2 and 3 while Western sites are FLX 4, 5, and 6.

Table 3. Cold hardiness of Riesling microclimate differences in the last two years of the study. Six different transects were collected with sites 1, 2, and 3 found along the East and Southeast side of Seneca Lake while 4, 5, and 6 are found along the Southwest and West side. Cold hardiness values denoted as degrees Fahrenheit. Min column denotes deepest cold hardiness each week across all sites. Max column denotes weakest cold hardiness of each week across all sites. Difference column denotes variation between these two states.

		FLX_1_1	FLX_1_2	FLX_1_3	FLX2_1	FLX2_2	FLX2_3	FLX3_1	FLX3_2	FLX3_3	FLX4_1	FLX4_2	FLX4_3	FLX5_1	FLX5_2	FLX5_3	FLX6_1	FLX6_2	FLX6_3	Min	Max	Difference
	12/6/2022	-10.8	-8.0	-8.6	-9.1	-9.2	-6.6	-8.5	-9.8	-9.4	-8.1	-3.7	-8.7	-7.5	-9.0	-5.6	-8.5	-8.3	-9.6	-10.8	-3.7	-7.1
	12/21/2022	-10.1	-10.1	-10.8	-6.9	-11.5	-11.6	-12.1	-9.8	-12.5	-10.6	-3.5	-12.5	-12.8	-11.9	-7.0	-11.7	-10.9	-8.4	-12.8	-3.5	-9.3
	1/4/2023	-11.2	-10.1	-7.9	-10.5	-12.0	-9.9	-9.4	-7.4	-10.8	-10.8	-5.3	-8.2	-10.9	-10.8	-6.1	-10.6	-8.6	-8.7	-12.0	-5.3	-6.7
	1/19/2023	-10.3	-9.1	-9.8	-9.0	-9.4	-3.0	-9.7	-8.7	-9.4	-5.0	-9.5	-11.7	-10.0	-7.9	-4.5	-8.3	-7.7	-7.1	-11.7	-3.0	-8.6
2022-2023	1/31/2023	-13.3	-11.8	-12.2	-15.1	-13.1	-11.0	-11.0	-11.3	-10.1	-13.7	-11.3	-12.9	-12.8	-12.2	-12.9	-13.5	-11.4	-10.6	-15.1	-10.1	-5.0
	2/14/2023	-10.9	-10.4	-8.6	-11.5	-11.4	-7.9	-7.5	-7.4	-8.3	-8.6	-11.8	-13.2	-7.2	-8.4	-11.7	-10.2	-11.1	-8.0	-13.2	-7.2	-6.0
	3/8/2023	-9.0	-8.4	-6.2	-7.6	-9.5	-7.2	-6.1	-3.8	-6.4	-7.5	-9.6	-10.8	-6.9	-6.2	-9.4	-7.8	-7.8	-5.8	-10.8	-3.8	-7.0
	3/17/2023	-5.9	-0.2	-2.1	-7.1	-6.2	-4.0	0.0	-1.9	-2.4	-5.4	-7.7	-5.3	-3.6	-4.4	-5.5	-6.4	-6.8	-3.4	-7.7	0.0	-7.7
	3/29/2023	0.1	1.5	0.8	-3.3	-1.6	-0.6	-1.3	6.2	3.6	-0.8	-5.0	-3.8	-0.7	1.5	1.1	-3.3	-5.1	0.6	-5.1	6.2	-11.3
	11/7/2023	4.8	1.8	3.5	1.8	-2.0	4.6	1.1	1.7	1.3	0.9	0.3	-1.8	2.4	4.3	-1.0	0.3	0.9	2.6	-2.0	4.8	-6.8
	11/21/2023	-4.9	-3.6	-6.6	-3.5	-5.5	-0.6	-4.7	-4.9	1.1	-5.5	-7.8	-8.8	6.3	-4.5	-4.3	-2.8	5.5	-2.2	-8.8	6.3	-15.1
	12/7/2023	-10.1	-10.0	-10.2	-10.7	-9.8	-10.2	-10.0	-8.9	-6.5	-9.5	-11.3	-9.1	-8.3	-10.3	-11.8	-7.4	-9.9	-7.8	-11.8	-6.5	-5.4
	12/19/2023	-10.9	-8.1	-7.4	-8.9	-14.2	-6.4	-5.4	-10.6	-9.6	-10.4	-10.9	-10.5	-9.8	-11.1	-12.6	-6.8	-5.5	-6.5	-14.2	-5.4	-8.8
2023-2024	1/3/2024	-10.2	-9.1	-9.2	-9.9	-10.6	-11.2	-9.4	-8.8	-9.6	-9.2	-11.5	-8.7	-6.3	-9.3	-11.5	-10.7	-10.5	-7.2	-11.5	-6.3	-5.2
	1/17/2024	-10.6	-9.9	-10.2	-10.9	-12.9	-12.0	-7.4	-10.7	-8.1	-10.5	-9.4	-8.1	-6.1	-8.9	-11.7	-10.6	-9.5	-9.3	-12.9	-6.1	-6.9
	1/30/2024	-10.2	-10.5	-10.0	-7.1	-10.5	-9.4	-5.6	-10.7	-7.7	-9.7	-10.6	-11.4	-9.2	-7.7	-10.5	-11.6	-7.8	-9.2	-11.6	-5.6	-5.9
	2/15/2024	-9.8	-7.7	-9.7	-6.0	-9.4	-8.5	-4.3	-8.4	-7.9	-7.1	-9.9	-9.3	-2.6	-5.5	-8.6	-5.3	-5.7	-7.3	-9.9	-2.6	-7.3
	2/27/2024	-7.5	-5.8	-7.4	-9.7	-10.1	-8.7	3.5	-5.9	-7.5	-9.0	-7.5	-6.5	-7.9	-6.7	-11.0	-8.7	-8.3	-5.8	-11.0	3.5	-14.5
	3/12/2024	-2.5	-1.7	-0.4	0.0	-2.6	3.9	5.3	1.8	0.6	-0.7	-2.9	-2.8	-0.8	2.1	0.6	-0.6	4.1	0.0	-2.9	5.3	-8.2
	3/26/2024	-1.8	-1.6	3.0	1.0	-2.0			1.4	2.8	-2.3	-3.8	-5.6	0.8	1.7	-0.3	0.1	0.4	0.9	-5.6	3.0	-8.6

Figure 4. Cold hardiness curves showing LT50 values for Concord samples collected in the Western NY region. Milder conditions during 2023-2024 tended to result in less cold hardiness at each site relative to the previous year's sampling. Clear evidence of mild winter rapid deacclimation at all sites.

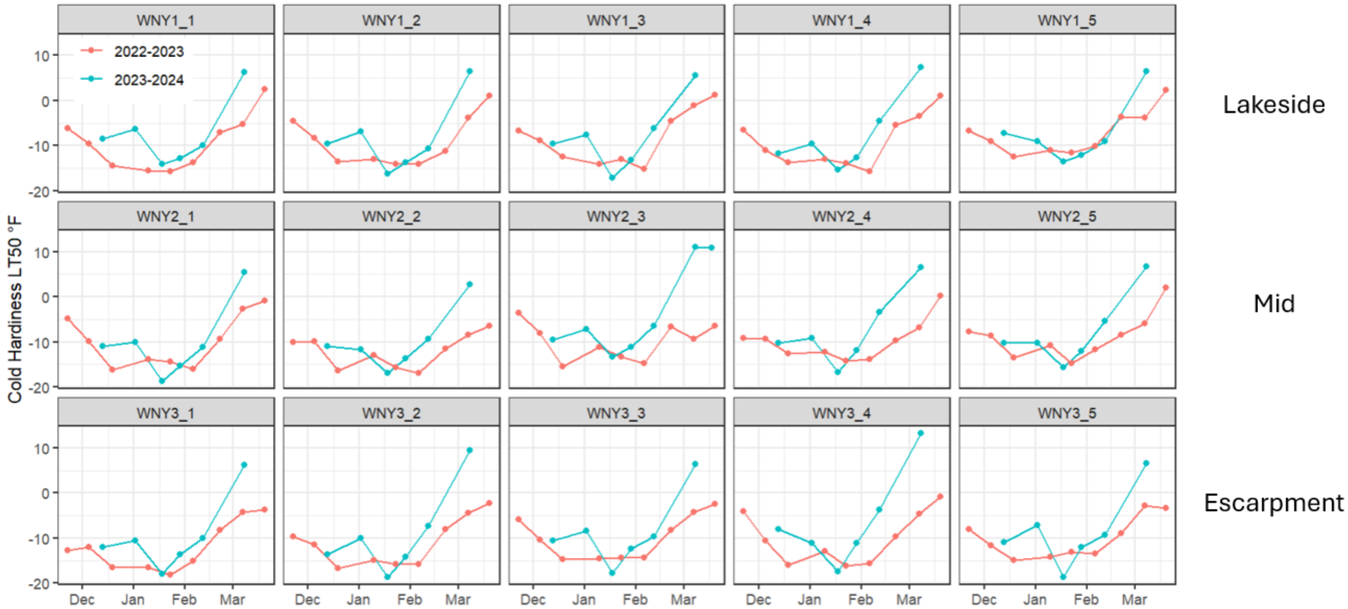

Table 4. Cold hardiness of Concord microclimate differences in the last two years of the study. Sites along Lake Ontario are denoted as WNY1, mid distance as WNY2, and escarpment sites as WNY3. Cold hardiness values denoted as degrees Fahrenheit. Min column denotes deepest cold hardiness each week across all sites. Max column denotes weakest cold hardiness of each week across all sites. Difference column denotes variation between these two states.

		WNY1_1	WNY1_2	WNY1_3	WNY1_4	WNY1_5	WNY2_1	WNY2_2	WNY2_3	WNY2_4	WNY2_5	WNY3_1	WNY3_2	WNY3_3	WNY3_4	WNY3_5	Min	Max	Difference
	11/22/2022	-6.1	-4.6	-6.6	-6.4	-6.6	-4.8	-10.1	-3.7	-9.2	-7.6	-12.8	-9.7	-5.8	-4.0	-8.1	-12.8	-3.7	-9.1
	12/5/2022	-9.6	-8.3	-8.8	-11.0	-9.0	-9.9	-10.0	-8.1	-9.4	-8.6	-12.0	-11.5	-10.4	-10.6	-11.7	-12.0	-8.1	-3.9
	12/19/2022	-14.4	-13.4	-12.5	-13.6	-12.4	-16.1	-16.4	-15.5	-12.6	-13.5	-16.5	-16.7	-14.7	-15.9	-14.9	-16.7	-12.4	-4.3
	1/10/2023	-15.4	-13.0	-14.0	-12.9	-11.1	-13.8	-12.9	-11.1	-12.1	-10.7	-16.5	-14.9	-14.5	-13.0	-14.1	-16.5	-10.7	-5.7
2022-2023	1/23/2023	-15.7	-14.1	-13.0	-13.8	-11.6	-14.4	-15.7	-13.2	-14.2	-14.7	-18.2	-15.7	-14.4	-16.1	-13.2	-18.2	-11.6	-6.6
	2/6/2023	-13.8	-14.1	-15.1	-15.7	-10.1	-16.0	-16.9	-14.8	-13.8	-11.6	-15.1	-15.7	-14.3	-15.7	-13.5	-16.9	-10.1	-6.8
	2/22/2023	-7.1	-11.1	-4.6	-5.5	-3.5	-9.4	-11.5	-6.7	-9.7	-8.5	-8.3	-8.0	-8.3	-9.7	-9.0	-11.5	-3.5	-7.9
	3/7/2023	-5.3	-3.8	-1.1	-3.5	-3.8	-2.6	-8.4	-9.4	-6.7	-5.9	-4.3	-4.4	-4.3	-4.6	-2.9	-9.4	-1.1	-8.3
	3/20/2023	2.5	1.0	1.3	1.0	2.3	-0.8	-6.5	-6.4	0.2	2.0	-3.6	-2.3	-2.4	-0.7	-3.4	-6.5	2.5	-9.0
	12/13/2023	-8.5	-9.5	-9.6	-11.7	-7.2	-10.9	-11.0	-9.5	-10.1	-10.2	-11.9	-13.5	-10.6	-7.9	-11.0	-13.5	-7.2	-6.4
	1/2/2024	-6.3	-6.9	-7.5	-9.5	-9.1	-10.0	-11.6	-7.2	-9.1	-10.3	-10.5	-10.0	-8.4	-11.2	-7.2	-11.6	-6.3	-5.3
2023-2024	1/18/2024	-14.1	-16.1	-17.1	-15.3	-13.4	-18.7	-17.0	-13.3	-16.7	-15.7	-17.9	-18.7	-17.7	-17.3	-18.6	-18.7	-13.3	-5.4
	1/29/2024	-12.8	-13.7	-13.2	-12.7	-12.0	-15.3	-13.6	-11.2	-11.9	-12.1	-13.6	-14.1	-12.3	-11.1	-12.0	-15.3	-11.1	-4.2
	2/12/2024	-9.8	-10.6	-6.2	-4.5	-9.1	-11.1	-9.3	-6.5	-3.4	-5.3	-10.0	-7.3	-9.6	-3.7	-9.2	-11.1	-3.4	-7.7
	3/8/2024	6.4	6.5	5.6	7.4	6.5	5.4	2.8	11.0	6.6	6.8	6.2	9.5	6.4	13.2	6.6	2.8	13.2	-10.4

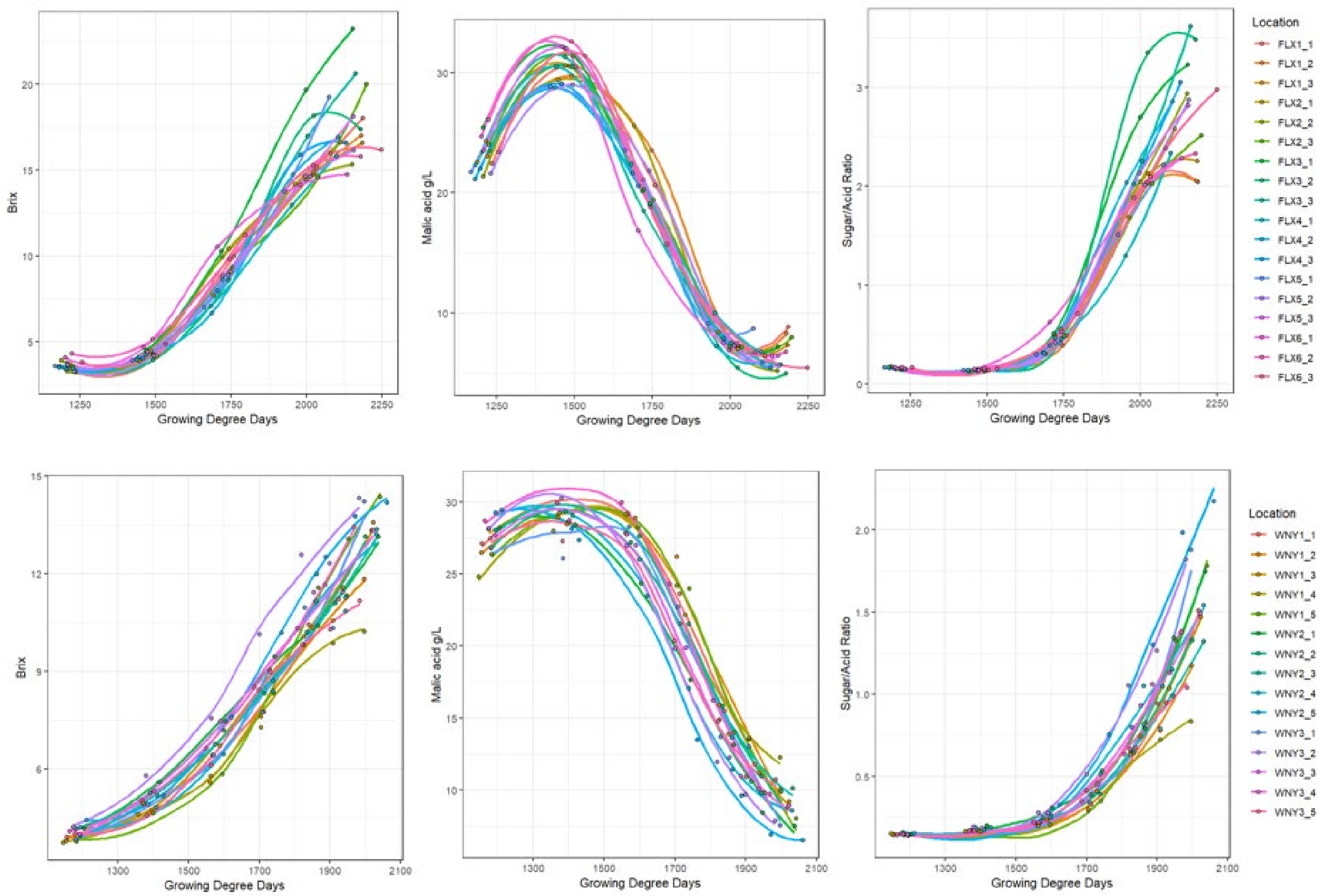

Figure 5. Brix, TA, and sugar/acid ratio for microclimate berry collections. X-axis has been converted from Julian day to growing degree days as computed from April 1 2023.