Snapshot report:* Modeling Winegrape Suitability for Common Varieties in British Columbia

Temporal Ecology Lab†

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*This is a shortened version of the Full Report by the same name.

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Background: What determines which grape varieties will grow well in a certain region is a critical question in viticulture. Fundamentally, vines are limited by climate—they cannot grow where it is too cold or too hot, or where seasons are too short to ripen fruit—and may also be limited by disease and insect pressures. Management techniques in agriculture can alleviate some of these limitations, but the fundamental constraints generally remain.

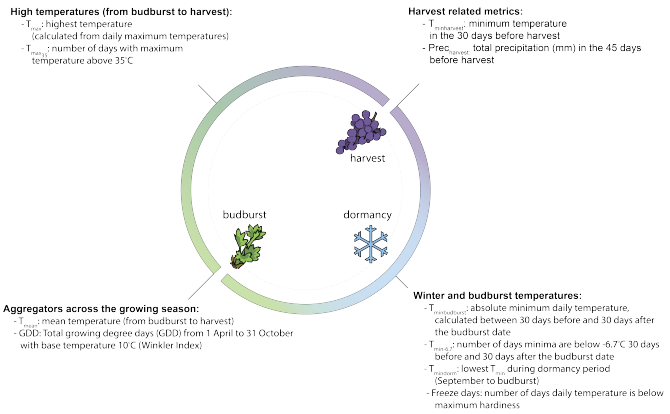

Figure 1: Our model used 10 different metrics that aggregate over important periods of the year for winegrapes.

Translating these biological limitations to where winegrapes can grow—and how agricultural practices may alter this—into models that predict variety suitability in different regions has traditionally been done through two major ways. First, distribution models (or 'species distribution models,' often called SDMs) predict suitability by combining a common set of climatic variables with information on where varieties are currently grown to predict suitability. These methods are designed to apply broadly, and are often used in both crop and wild species, but they fail to integrate any known physiological or other constraints (1; 2). For example, in winegrapes, the maximum cold extremes that different varieties can withstand is often known (3; 4; 5), but would not be included in a standard 'bioclimatic' distribution model. Addressing this gap, other models use bespoke climatic indicators selected for each crop based on existing knowledge. They then build models that include known constraints—for example, what temperatures are too cold or what amount of heat is needed to ripen fruit—and use additional information on where plants grow to inform suitability.

Here, we present results from distribution models using high-resolution historical climate from the past 30 years of climate in British Columbia's winegrowing regions. These results provide a 'first-pass' to try to begin to understand the suitability of different varieties in BC, but have major limitations, which we outline below in *Limitations & Opportunities*.

Results: Our results—based on historical climate data (over the last 30 years)—highlight that variety suitability varies by location, but also the method for determining suitability. Our approach using known physiological limits specific to winegrapes, such as freeze limits (Fig. 2) found limited suitability across some regions. (See full report for discussion of alternative models for estimating suitability that found limited, but generally greater, suitability.)

These results suggest the Okanagan and Similkameen Valleys are suitable for the

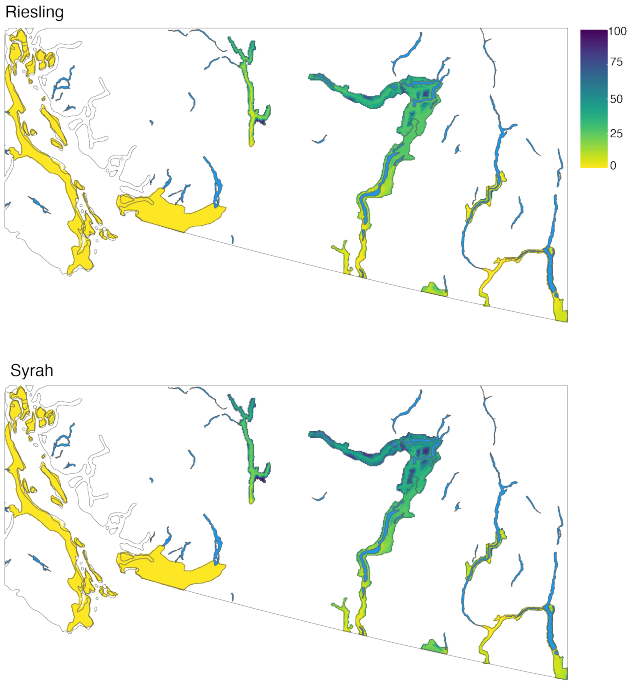

Figure 2: Percent of years with at least one day below the maximum estimated hardiness for two varieties from (5), estimated using 1 km x 1 km Daymet data over the last 30 years. Riesling is generally much hardier than Syrah, which is captured here though more regions showing more freeze events for Syrah.

most varieties across at least 20% of each
region, while the Gulf Islands and Vancouver Island are not suitable for most (Fig. 3). These latter regions were limited by GDD. Thompson and Shuswap Valley and Kootenay Arrow Lakes also showed limited suitability. The major limiting factors for variety suitability varied by region with Lillooet, Shuswap Valley, Thompson Valley and parts of the Okanagan and Kootenary regions limited by freeze days (which generally co-varied with frost risk in the spring) while most of the Gulf Islands, Vancouver Island and Fraser Valley were far more limited by low GDD. Most varieties were suitable in only 3-4 regions, except for Syrah which was only suitable in the Okanagan and Similkameen Valleys. Suitability varied across regions. The smaller Similkameen region showed higher suitable in part based on its size. In the Okanagan higher suitability was common in southern areas for all varieties. Within the Fraser valley, warmer interior parts had higher suitability, though only for a limited subset of varieties (Fig. 3).

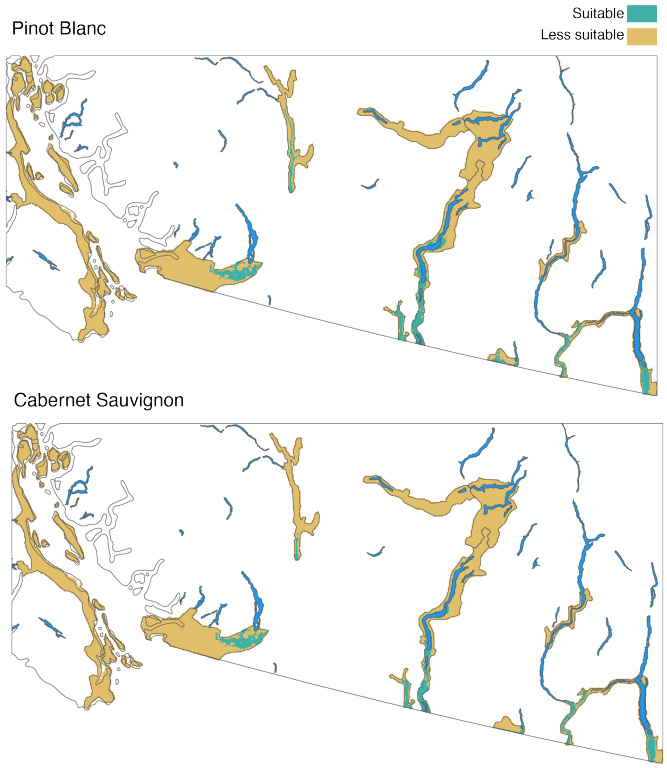

Figure 3: Areas considered suitable based on a model including known physiological limits and climate metrics specific to winegrapes and 1 km x 1 km Daymet data over the last 30 years. Here we show two varieties which showed different suitability: Pinot Blanc and Cabernet Sauvignon. For maps of 12 varieties, see the full report.

These results are based on historical climate and thus unlikely to be accurate for future climate. BC winegrowing regions are warming (Fig. 4)—and given their northern latitudes we would expect them to be warming faster than most other regions (6). Over our historical 30 year period warming appears most pronounced in summer (June-August), with temperatures 2°C higher in recent years compared to the mid-1990s. Warming trends were less obvious from December-February, which may explain the persistence of winter cold snaps while the region is also facing hotter, drier and more fire-prone summers.

Limitations & Opportunities: Estimates of variety suitability for winegrowing regions are fundamentally limited by data and models. The results we present here benefit from cutting-edge historical climate data, gridded to allow us to provide fine-scale (1 km x 1 km resolution) across BC growing regions and phenological models based on the world's largest collection of winegrape phenological data. They also critically rely on variety-specific hardiness models derived from long-term hardiness data measured by AgCanada's Summerland Research and Development Centre.

Variety suitability in this report still represents a limited set of estimates for an extremely limited set of varieties and is thus more backward than forward-looking. Given growing interest in BC in variety suitability, however, there is momentum to quickly and grossly improve these estimates through:

1. Integrating climate projections: Given how rapidly BC's climate is warming, suitability estimates (such as those presented here) based on historical climate provide only a starting point and should be compared to suitability estimated from climate projections based on different

scenarios over different periods. For example, a clear next step would be suitability estimates based on mid-century climate under low and high emissions scenarios. Such suitability estimates would likely be most robust if produced by methods that merge biological models of plant development with climatic distribution models to try to dynamically predict suitability as climate changes, which relates to the next two areas for improvement.

2. Improving phenological models would likely alter our suitability estimates. For this rapid analysis we used published global estimates of budburst and harvest dates (7), which allowed us to estimate winegrape relevant climate metrics (Fig. 1)—a major improvement over most standard methods. These budburst and harvests dates, however, were based on coarse-scale climate: they used a climate gridcell of 100 km x 100 km and averaged over climate of the 1970s. Not surprisingly they predicted late budburst and harvest for several varieties in BC that are likely inaccurate for regions where grapes are grown today in the current (warmer) climate. Given additional computational and analysis time, these models could be re-built using existing data from the Okanagan and the new gridded climate dataset we used here, which would likely increase the suitability of several varieties in parts of BC.

3. Calculating daily hardiness across North America for historical and projected climate would provide major insights in how cold has and will limit suitability across BC. For the analyses here, we used Okanagan-specific estimates of maximum hardiness, which we had for major varieties. We compared these estimated freeze days from this approach to a daily hardiness model (provided by Al Kovaleski), which suggested our analyses are likely overly optimistic for loss due to cold damage. We found generally more potential freeze events using the daily hardiness model, which more accurately captures fluctuating hardiness (for the two varieties with daily hardiness models). Daily hardiness models at the fine scale of our climate data are computationally challenging, but possible and would give growers greater insights onto their risks due to cold, especially in the early fall and spring currently. Further, daily models would be critical for accurate estimates of potential freeze events as the climate warms if vines fail to gain maximum hardiness (if average winter temperatures rise).

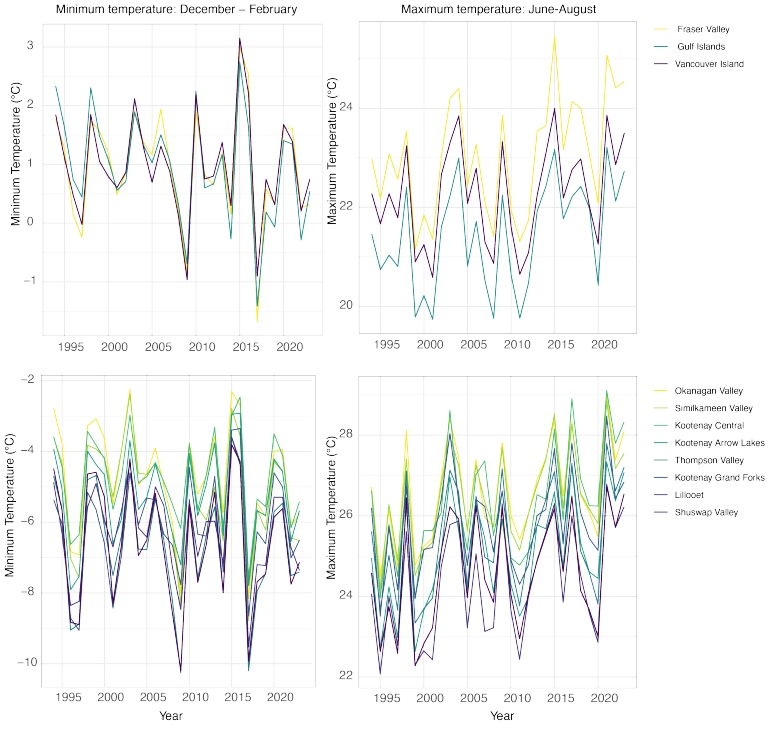

Figure 4: Trends in winter minimum temperatures (left) and summer maximum temperatures (right) over the last 30 years for coastal (top) and inland (bottom) growing regions.

4. Expanding beyond commonly planted varieties. This analysis focused on 12 major varieties commonly planted in BC winegrowing regions today. This represents only 1% of the total diversity of winegrapes planted today (and this considers only non-hybrid varieties), capturing a tiny fraction of the possible diversity that could be used—including for blending varieties (varieties used to make the wine, but included in a lower proportion and thus often not required to be included on the label). Previously, BC has formally tested dozens of varieties (a 1984 report mentions over 112 varieties that had been tested by 1947), but this tradition has clearly died

out leaving growers and researchers alike with a limited set of varieties to consider for planting. Winegrape suitability in BC would increase with an increasing set of varieties considered.

The above areas are critical research needs if BC growers want better estimates of variety suitability. They would give growers a much fuller picture of future suitability, more varieties to consider and a more nuanced picture of how limits to suitability, such as cold events, will shift in the future.

Growers may also want to explore suitability as defined by their own management strategies, wine styles and the level of risk due to cold damage they consider 'suitable.' For example, we found much of the Gulf Islands, Vancouver Island and Fraser Valley regions limited by GDD, but these regions may be able to ripen grapes in many years for lighter style wines or sparkling wines. Our current analyses could easily be adapted to define suitability depending on different wine styles. Similarly, growers may consider some of our metrics less relevant and want to examine how suitability changes when some metrics are excluded. Similarly, these analyses could be adjusted to allow more freeze years per 10 year period. With this information, growers will still have to make fundamental choices about their risk tolerance, however.

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