Chapter 8
Spatial Analysis of Climate–Viticulture Indices for the Eastern United States

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ABSTRACT

This study characterizes the climate structure in the Eastern United States for suitability of winegrape growth. For this study, the Eastern US is defined as the 44 contiguous Eastern most states. This excludes the premium wine growing states of California, Washington, Oregon and Idaho. For this characterization, a comparative study is performed on the four commonly used climate-viticulture indices (i.e., Average Growing Season Temperature, Growing Degree Days, Heliothermal Index and Biologically Effective Degree Days), and a new climate-viticulture index, the Modified-GSTavg (Mod-GSTavg). This is accomplished using the 1971 – 2000 PRISM 800-meter resolution dataset of climate temperature normal for the study area of 44 states and 62 American Viticultural Areas across the Eastern United States. The results revealed that all the climate indices have similar spatial patterns throughout the US with varying magnitudes and degrees of suitability.

INTRODUCTION

Climate plays an important role in agriculture. Crucial decisions, such as crop growth monitoring, irrigation, harvest management, crop selection, and adaptation are all based on understanding how climate interacts and affects crop growth and production. Viticulture shares these climate-driven management concerns and decisions, relying heavily on understanding the climate within the grape growing region, which ultimately contributes to proper vineyard planning and maintenance. (Jackson 2001; Jackson & Spurling 1988; Jackson & Schuster 1987; Jones 2006; Jones & Davis, 2000(a) and (b); Smart & Dry 1980; Tonietto & Carbonneau 2004; Van Leeuwen et. al, 2004; Winkler et al 1974).

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Regional and local climate is essential for determining vineyard site suitability (Winkler et al 1974, Plocher & Parke 2001). Important climate factors include temperature, humidity, precipitation, sunshine and wind. Each of these variables has a different degree of importance and influence on winegrape growth and development. However, past studies have shown that temperature plays a dominant role (Jackson 2001; Jackson & Schuster, 2001; Kobayashi et al1967; Plocher & Parke, 2001; Pool 2000; Winkler et al 1974). Cooler climates, with a monthly mean pre-harvest temperature below 15°C (59°F) has a significant challenge for winegrape growth and maturity, . This climate type produces grapes with lower sugar levels, higher acid levels, high pH levels, and lower yields (Jackson 2001). These cooler climates are generally found at higher altitudes and latitudes. Winkler et. al (1974) found that maximum elevations for winegrape growth is 5000 – 6500 ft (1524 – 1981 m), since higher altitudes are generally cooler. However, in areas with extremely warm temperatures, winegrape cultivation can thrive at higher altitudes (Van Leeuwen and Seguin 2006; Van Leeuwen et. al, 2004).

It is temperature that determines the growing season length and evolution and how the winegrape matures. The winegrape growing season is considered to be the Frost Free Period, which is defined as time period between the last spring freeze and the first fall freeze (Wolf and Boyer 2009), and should be greater than 170 days (Pool 2000). Crop freezing occurs somewhere between -2.22°C (28°F) and 0°C (32°F). Although these limits define the actual growing season, vine shoot growth does not actually occur until temperatures reach 10°C (50°F) (Wolf 2008). With adequate soil water, nutrients and insolation, after bud break, temperature largely dictates shoot growth and berry ripening. Each growth stage must be long and warm enough to support sufficient berry development, growth rates and sizes. Kobayashi et al (1967) found that an average daily temperature of 22°C (71.6°F) was the most suitable temperature for grape yield and quality, and daily average temperatures greater than 30°C (86°F) were unsuitable.

Several authors have studied climate impact on viticulture in the premium wine regions of the Western United States, Europe, and Australia (Blanco-Ward et. al 2007; Dry & Smart 1988; Gladstones 1992; Jackson & Cherry 1998; Jones 2009a and b; Jones & Davis 2000a; Tonietto & Carbonneau 2004; Winkler et al 1974). Premium wine regions are defined as having long established *V. Vinifera* grapes, such as Cabernet Sauvignon or Chardonnay. The goal of these studies was to analyze general climate aspects, assess the suitability of establishing and maintaining vineyards and create climate-viticulture indices which support the suitability.

Commonly used viticulture climate indices are based on average growing season temperature, or other aspects of climate and terroir. Amerine and Winkler (1944) created on of the first California winegrape growing climate classification based on temperature and heat summation, often referred to as the "Heat Summation" or "Degree Day" method. In this method, the mean monthly temperature above 1°C (50°F) is summed from April to October and expressed in degree-days. Heat summation ranges were created based on particular California regions.

Derived from Winklers' Heat Summation method, the Biologically Effective Degree Day (BEDD) and the 19/10 Calculations (Gladstones 1992) are also commonly used to calculate degree-days. In the BEDD method, the summation of degree-days is limited to days between 10°C and 19°C (66.2°F) and adjusted for latitude and daily temperature range. The 19/10 calculations differ from the BEDD method by truncating the mean temperatures at 19°C, and thresholding a monthly maximum of 279 degree days.

Huglin's (1978) Heliothermal Index (HI), uses daily temperatures and a day length coefficient to calculate an index to establish when the best potential grape sugar content. Smart and Dry (1980) developed an index which was based on five climate parameters: average temperature in the hottest month, Continentality (difference between the temperature in the hottest month and the coldest month), total