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UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE
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Vineyard Site Selection

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Successful viticulture begins with selecting a suitable vineyard site. Therefore, site selection is the most important decision a prospective grower makes when considering grape growing on a commercial scale. The decision to where to plant the vineyard will affect yields and profitability for the rest of the vineyard life (20 to 40 years). There are three aspects that should be considered when selecting a vineyard site: climate, soils and proximity to crop hazards

1) Climate

Climate is defined as the prevailing weather of a geographic region. There are three categories of the climate that prospective vineyardists have to consider: macroclimate, mesoclimate and microclimate.

Macroclimate is the climate of a large region measured in many square miles. For example, the lower Midwest region is characterized by a continental climate where temperatures fluctuate on a day-to-day basis. The macroclimate in Kentucky is characterized as humid, and continental with severe winter temperatures and warm summer temperatures. The conditions in these climates are excellent for the growth of annual row crops. Most rainfall occurs in the summer months. However, in some years rainfall is sparse, resulting in drought. The fluctuation of daily temperatures during midwinter is usually more harmful to grapevines than steady cool temperatures.

Minimum winter temperature is the most important factor influencing the distribution of the fruit industry. Occurrences of critical temperatures actually define where perennial fruit crops can be grown. Many of the fruit species were either bred for specific fruit quality factors or have been moved from the climate in which they evolved. Thus, many domestic forms are not completely adapted to the environment in which they are cultivated. Even in established fruit growing areas, temperatures occasionally reach critical levels and cause significant damage. The moderate hardiness of grapes increases the likelihood for damage since grapes are the most cold-sensitive among temperate fruit crops.

Freezing injury, or winterkill, occurs as a result of permanent parts of the grapevine being damaged by sub-freezing temperatures. This is different from spring freeze damage which kills emerged shoots and flowers buds, therefore the crop. Thus, winterkill can be much more costly, as entire plants can be destroyed, not just the crop. Common injuries include winter sunscald, frost-splitting of trunks, death of dormant buds, stem blackening, and death of tissue in twigs, branches and trunks. However, the injuries listed do not occur indiscriminately; many factors of plant hardiness and health determine the probability and extent of such injuries. Levels of damage from minimum temperature exposure have been linked to tissue type; level of plant dormancy and season; fluctuating mid-winter temperatures; and plant size, wood maturity, and variety hardiness. Hardiness is a product of not only the lowest temperatures that a plant can withstand, but also how well the plant acclimatizes to the winter conditions of an area.

The protection of cultivated plants against winter injury may present problems not found in natural environments. Grapes have been subjected to this exact circumstance for hundreds of years, but there exist many cultural practices which have augmented the ability of fruit species to survive outside of their indigenous range. In general, the hardiness of the major temperate fruit crops, from hardiest to most sensitive is best summarized as follows: apple>pear>plum>cherry>peach/grape. This means that most apple and pear cultivars can withstand lower temperatures than can the peach or grape, and possess superior acclimation processes. However, great variation occurs within and among each fruit crop, with native varieties and hybrids being naturally hardier than introduced ones. As an example, cold hardiness of grapevines can be classified as follows: *V. riparia* (hardiest) >*V. labrusca*>'hybrids' (interspecific crosses) >*V. vinifera*>*V. rotundifolia* (most sensitive). The greater hardiness of the hybrids is the main reason they became established in the eastern United States before vinifera.

A prerequisite for understanding minimum temperature occurrence is an understanding of the two main types of freezes: **advective** and **radiative**. Radiative freeze events usually occur during calm, clear weather as the ground cools – by infrared radiation to space after sunset. As the ground heat dissipates into the atmosphere, the ground becomes cooler, and begins to cool the air directly above it. Since the earth, and air, are naturally cooler at higher elevations--a product of the atmospheric lapse rate--they cool more quickly. Cold air is much denser than warm air, and will actually begin to flow in a viscous manner, from high to low areas, when these radiative conditions prevail. The flowing cold air 'fills' lower lying areas, displacing warmer air upwards; thus creating a temperature inversion, where temperature increases with altitude - the inverse of atmospheric lapse.

Advective freezes involve the movement of an entire frontal system of cold air across the landscape. These polar-derived cold air masses tend to be turbulent, and rapidly moving, allowing little or no temperature stratification near the ground. They are also termed 'top-down' freezes because the standard atmospheric lapse rate, or decreasing temperature with increasing altitude, usually holds true. Both types of freezes can produce critical temperatures at any time; however, radiative freezes usually happen in spring and fall, while advective freezes are most prevalent in winter. The frequency of critical temperature occurrence in a given region is the basis for identifying minimum temperature hardiness zones.

The frequency of specified critical temperatures can be predicted for a proposed vineyard site on the basis of historical temperature data and the proposed site's elevation. The predominance of French-American hybrid acreage in Kentucky supports the use of -15^{o}F as a critical threshold for predicting significant cold injury. Hybrid cultivars exposed to -15^{o}F may sustain 50% primary-bud injury, and possibly cane, cordon or trunk injury. This threshold is representative of moderately cold-hardy hybrids (e.g. 'Chambourcin', 'Chardonel', 'Seyval blanc', 'Vignoles') that are predominantly grown in Kentucky. However, setting a critical threshold at -15^{o}F would not exclude injury at warmer temperatures since cold hardiness varies with cultivars, acclimation and season.

The *length of the growing season* is another consideration in selecting a suitable vineyard site. The number of frost-free-days (FFD) is between the last spring frost and the first killing fall-frost. Grape varieties have different requirements of growing season length to commercially ripen fruit and harden-off for the upcoming winter. As a general rule of thumb, grapevines require between 150 FFD (early ripening varieties) and 190 or more FFD (late varieties). The frost-free-day means for Kentucky are depicted in Figure 1.

Growing Degree Day (GDD) summation (50^{o}F base) between 1 April and 31 October has been used to predict the vine's ability to mature a high quality crop in the northern hemisphere (Amerine and Winkler, 1944). Therefore, suitability models must measure heat unit accumulation to ensure sufficient crop maturity. The Amerine and Winkler GDD summation divides the viticultural area into five regions based on the GDD summation. The region I is characterized as regions accumulating less than 2500^{o}F or fewer GDD, region II accumulating between 2501^{o}F and 3000^{o}F GDD, region III 3001^{o}F to 3500^{o}F GDD, region IV between 3501^{o}F GDD to 4000^{o}F GDD, and region V more than 4000^{o}F GDD. The growing degree day accumulation in Kentucky is depicted in Figure 2.

Mesoclimate is the climate of the vineyard site affected by its local topography. The topography of a given site including the absolute elevation, slope, aspect and soils will greatly affect the suitability of a proposed site. Mesoclimate is much smaller in area than the macroclimate.

Absolute and relative elevation: The physics of topographic effects on air temperature are well documented and its horticultural significance well appreciated. Under radiative cooling conditions, with calm winds and clear skies, the earth loses heat to space and cools the adjacent layer of air. If the vineyard is on a slope, the cold, relatively dense air moves downhill. The sinking, cold air displaces warmer air to higher elevations producing thermal inversions or thermal belts. Above the warm belts, air temperature again decreases at an average rate of $3.6^{o}F \cdot 1000\ feet^{-1}$ of increase in elevation. The sinking, cold air collects in low-lying areas and will create frost pockets.

A combination of local experience and research was used to help define the upper and lower limits of the desired thermal belt for the mount/valley regions of Virginia and Illinois. It was estimated that the upper limits of the thermal belt ranged from 1500 feet above sea level in Northern Virginia, to approximately 2000 feet in the southern portion of the state. For a county that ranged in absolute elevation from 200 to 2300 feet the best elevation range was estimated to be 680 to 1500 feet above sea level (asl). In southern Illinois, for counties that ranged in absolute elevation from 300 to 900 feet asl, the best elevation range was measured to be 750 to 900 feet.

The relative elevation of the site is also important and must be considered in tandem with the absolute elevation. Relative elevation refers to the position of a site based on its elevation relative to surrounding sites. Poor relative elevation can reduce the quality of an otherwise good absolute elevation site. Small valleys that are perched in mountainous areas, even though they may fall within the best absolute elevation range may still lie in ponds of cold air drainage. These areas are thus subject to increased frequency of frost and winter injury.

<u>Slope:</u> The slope is the inclination or the declination that of land surface varies from the horizontal and is measured as a percentage of elevation change over horizontal distance. Perfectly flat land would have a slope of 0% and vertical cliffs would have a slope of 100%. A slight to moderate slope (5% to 10%) is desirable in vineyard sites as it accelerates the drainage of denser cold air from the vineyard. Cold air is denser than warm air and will drain downhill. Lands sloping greater than 15% are not recommended because it is hazardous to operate equipment on steep slopes and these lands erode readily.

<u>Aspect:</u> The aspect of a slope is the prevailing compass direction which the slope faces. Aspect affects the angle that the sunlight hits the vineyards and thus its total heat balance. Even in warm grape growing regions vineyards should be exposed to direct sunlight at least for a portion of the day. Eastern exposures provide optimal exposure. The early morning exposure hastens onset of photosynthesis and speeds drying of dew on the foliage and fruit. Vineyards with southern and western aspects can warm earlier in the spring, and the vines may undergo budbreak earlier than vineyards with northern slopes. Southern aspects in the northern hemisphere can lead to early deacclimation of grapevines during mid-winter (January – thaw).

Aspect also has an effect on winter temperatures. Johnstone et al. (1968) reported that minimum temperatures on northerly slopes in Georgia were $1.0^{o}F$ to $2.5^{o}F$ cooler than the corresponding elevations of southerly slopes during freezes with temperature inversions. In the same study, the frost-free growing season was on average about two weeks longer on the slope with the southern aspect than on the corresponding slope with the northern aspect.

Microclimate is the environment within and around the canopy of the grapevine. It is described by the sunlight exposure, air temperature, wind speed and wetness of leaves and clusters.

2) Soil requirements

Grapevines are grown in a wide range of soil types around the world. Soil affects grapevine productivity and wine quality and it is comprised of many components.

Internal water drainage: The best vineyard soils are those that permit deep and spreading root growth and provide a steady, moderate supply of water. The internal water drainage of vineyard soils is the most important soil physical property and the desirable value is > 50 mm per hour. This property can be modified with tile drainage during site establishment but adds to the cost of the establishment.

Organic matter: Organic matter contributes porosity, structure, nutrients and moisture to the vineyard soils. The organic matter provides a pool of slowly available nitrogen to support vine growth. Organic matter values greater than 3% to 5% may be counter-productive in that excessive nitrogen that is released by organic matter decomposition may lead to excessive vegetative growth. The desired range for vineyard soils is 2% to 3% of organic matter.

Texture: The direct effects of soil texture (proportions of sand, silt and clay) on wine quality are poorly defined, but the indirect effects of texture on soil hydrology are more important. Texture affects the water-holding capacity of the soils and internal water drainage. Ideal vineyard sites would have loam, sand loam or sand clay loam textures.

Soil pH: Soil pH can be modified during site preparation with lime or sulfur applications. Soil pH values between 6.0 and 6.8 provide the optimum availability of nutrients in vineyard soils. Soil pH less than 5.0 increases the aluminum solubility within the root zone and precipitates essential micronutrients such as iron out of the soil solution. However, there are grape cultivars that prefer low soil pH <5.5 e.g. 'Concord'.

3) Proximity to crop hazards

Elements outside climate and soil requirements must be considered during site selection for vineyards. These include herbicide drift and wildlife.

Growth regulator type herbicides such as 2,4-D are frequently used in row crops, right of ways and golf course. Grapevines are very sensitive growth regulator type herbicides and serious injury such as stunting during establishment can occur from drift onto the grape leaves. These high risk areas should be avoided during site selection.

Deer depredation affects young and mature vines. It is most devastating in newly established vineyards where foliage is damaged by the deer. Sites close to woodlands are most prone to deer damage. The extent and cost of protection methods depend on the severity of deer depredation.

Birds also cause serious crop loss in vineyards by consuming berries when the sugar to acid ratio of the berries reaches palatable levels. Proximity of the vineyards to wooded areas, power lines increases the risk of bird damage.

Summary: Suitable vineyard site matched to appropriate cultivars is the determining factor for economic success in commercial grape production. Keeping in mind that no site is perfect, in selecting a vineyard more emphasis should be placed on climate and topography of the site than on soil characteristics. The ideal vineyard is located in the highest surrounding area with a gentle sloping terrain where critical winter temperatures occur once or twice in a 10 year period and spring and fall frosts are minimum. Soils are deep and well-drained, and soil organic matter percentage is moderate. The vineyard site is not surrounded by woods and far away from drift of growth regulator type herbicides. An example of grape cultivars with various cold hardiness levels and corresponding minimum temperatures at which injury begins in presented in Table 1.

Table 1. Example of grape cultivars recommended for the lower Midwest with color, winter hardiness, expected ripening date and average cluster weight in pounds (after Dami, et al., 2005, and Zabadal and Andersen, 1997)

Cultivar	**Color**	**Winter hardiness**	**Days from bloom to harvest**	**Ripening date**	**Average cluster weight (lbs)**
Cayuga white	White	-10°F to -20°F	100	Midseason	0.33
Chambourcin	Blue	-10°F to -20°F	115	Late	0.42
Chancellor	Blue	-15°F to -25°F	100	Early midseason	0.25
Chardonel	White	-10°F to -20°F	110	Late midseason	0.36
Frontenac	Blue	-20°F to -35°F	100	Late midseason	0.27
GR-7	Red	-15°F to -25°F	100	Midesason	0.31
LaCrescent	White	-20°F to -35°F	105	Late midseason	0.24
LaCrosse	White	-20°F to -35°F	104	Late midseason	0.25
Leon Millot	Blue	-20°F to -35°F	85	Early	0.18
Marechal Foch	Blue	-20°F to -35°F	90	Early	0.20
Norton	Blue	-20°F to -35°F	120	Late	0.18
St. Croix	Blue	-20°F to -35°F	99	Early midseason	0.24
Seyval blanc	White	-15°F to -25°F	100	Early late midseason	0.43
Traminette	White	-10°F to -20°F	110	Late midseason	0.24
Vidal blanc	White	-10°F to -20°F	110	Late midseason	0.34
Vignoles	White	-15°F to -25°F	105	Midseason	0.17

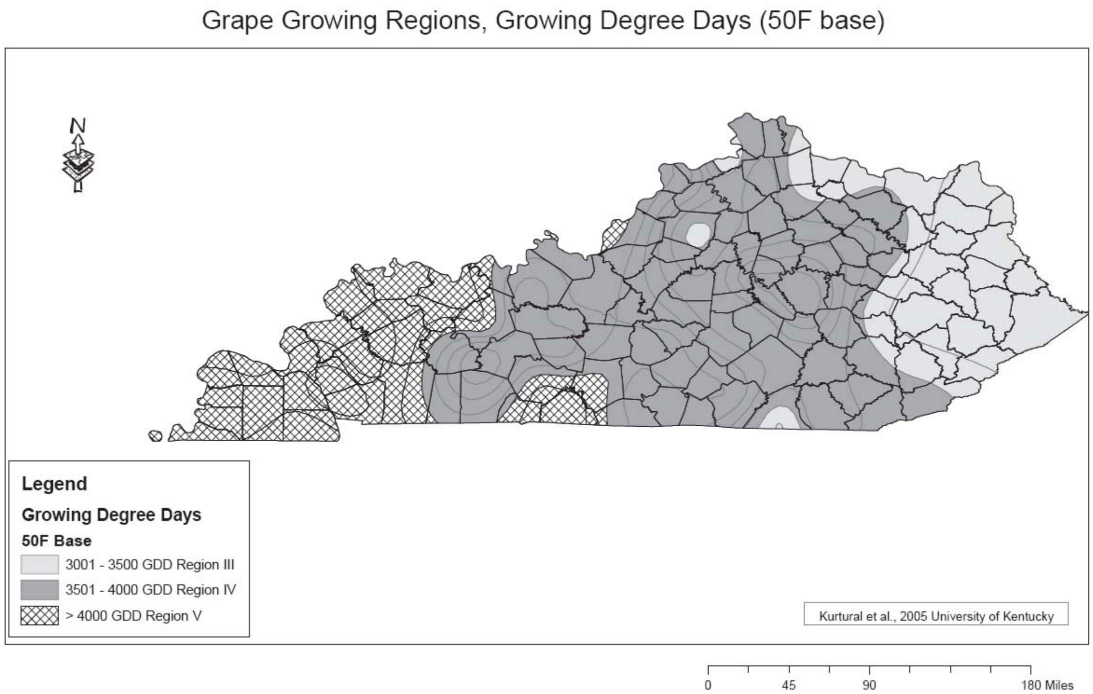

Figure 1. Grape growing regions in Kentucky based on Growing Degree Days (50°F base).

Grape Growing Regions, Frost Free Days in Kentucky (>32F)

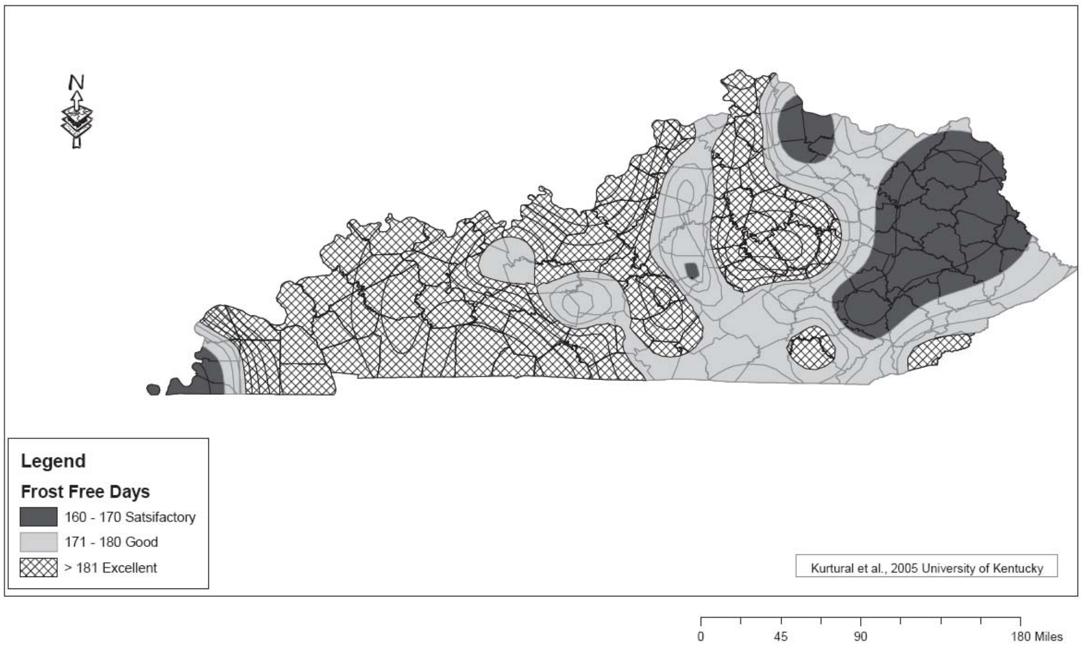

Figure 2. Grape growing regions based on Frost Free Days (length of growing season) in Kentucky.

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