HO-88

UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY — COLLEGE OF AGRICULTURE

Kentucky Viticultural Regions and Suggested Cultivars

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Grapes grown in Kentucky are subject to environmental stresses that reduce crop yield and quality, and injure and kill grapevines. Damaging critical winter temperatures, late spring frosts, short growing seasons, and extreme summer temperatures all occur with regularity in regions of Kentucky. However, despite the challenging climate, certain species and cultivars of grapes are grown commercially in Kentucky. The aim of this bulletin is to describe the macroclimatic features affecting grape production that should be evaluated in the site selection process and to shorten the trial and error process of finding the best cultivar and climate match.

Climate

Climate is defined as the prevailing weather of a geographic region. Prospective vineyardists must consider three categories of climate: macroclimate, mesoclimate, and microclimate.

Macroclimate is the climate of a large region measuring 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.

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 macroclimate.

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.

Components of Macroclimate

Many prospective vineyardists will have a narrowly defined interest in vineyard site selection. Some regions in the world have had hundreds and thousands of years to define, develop, and understand their macroclimatic regions, but newer regions such as Kentucky typically face a trial and error process of finding the best cultivar and macroclimate match. The macroclimate is analyzed as follows for viticultural purposes.

Dormant Season

Critical Low Temperature Frequency

Low temperature injury is the factor determining the distribution of grapevines on earth. Many 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 they are the most cold-sensitive of the temperate fruit crops.

Freezing injury, or winterkill, occurs as a result of permanent parts of the grapevine being damaged by subfreezing temperatures. This is different from spring freeze damage that kills emerged shoots and flower buds. Thus, winterkill is 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, mid-winter temperature fluctuation, plant size, wood maturity, and cultivar hardiness. Hardiness is a product of not only the lowest temperatures that a plant can withstand but also how well the plant acclimates 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 severe winters and late spring frosts for thousands of years, but many cultural practices exist that can augment 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:

most hardy
↑
apple
pear
plum
cherry
peach/grape
↓
least hardy

This means that most apple and pear cultivars can withstand lower temperatures than can the peach or grape, and they possess superior acclimation processes. However, great variation occurs within and among each fruit crop; native and hybrid cultivars are naturally hardier than introduced ones. As an example, cold hardiness of grapevines can be classified as follows:

most hardy
↑
V. riparia
V. labrusca
hybrids (interspecific crosses)
V. vinifera
V. rotundifolia
↓
least hardy

The greater hardiness of the hybrid grape cultivars is the main reason they became established in the eastern United States over vinifera.

A prerequisite for understanding minimum temperature occurrence is an understanding of the two main types of freezes: **advective** and **radiative**. 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; 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. Advective freezes affect the occurrence of minimum winter temperatures and therefore the commercial success of vineyards in Kentucky.

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. Because the earth and air are naturally cooler at higher elevations, 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 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 frequency of specified critical temperatures can be predicted for a proposed vineyard site on the basis of historical temperature data, the proposed site's elevation, and latitude. The threshold at which 50 percent of the primary grape buds are killed (economic failure of the crop) at maximum hardiness level is presented in Table 1. Hybrid cultivars exposed to -15˚F may sustain 50 percent primary-bud injury, and possibly cane, cordon, or trunk injury. This threshold is representative of moderately cold-hardy hybrids (e.g. "Chambourcin", "Chardonel", "Traminette," and "Vidal blanc") that are predominantly grown in Kentucky. However, setting a critical threshold at -15˚F would not exclude injury at warmer temperatures since cold hardiness varies with cultivars, acclimation, and season. Figure 1 depicts the occurrence of -15˚F between 1974 and 2005 in Kentucky.

Table 1. Temperature required to kill 50 percent of the primary buds in commercially important wine grape cultivars in Kentucky during January (Bluegrass region).

Relative Coldhardiness of Cultivar	Cultivar	Lethal temp. (ºF)
Hardy	Norton[a]	-22
	Chancellor	-18
	GR7M	-18
	Seyval blanc	-18
	Vignoles	-18
Moderately hardy	Chambourcin	-15
	Chardonel	-12
	Traminette	-12
	Vidal blanc	-12
Tender	Cabernet Sauvignon[b]	-5

[a] Although the Norton grapevine is hardy, it should only be planted in regions with greater than 181 frost-free-days and greater than 4000 growing degree days to ensure proper ripening.
[b] The commercially available clone 337 on C3309 rootstock was used in tests.

The occurrence of -15˚F happens with varying regularity in Kentucky. Regions that experience -15˚F less than 5 percent of the time in a 30-year period are suitable for the most tender hybrid cultivars. Kentucky counties Pike, Martin, Floyd, and Letcher (eastern); Daviess, Breckenridge, Butler, Warren, McCracken, Caldwell, Graves, Lyon (western); Shelby, Jefferson, Spencer, Lincoln, Casey, Taylor, Whitley, and Bell experience -15˚F events less than 5 percent of the time in a 30-year period (Figure 1). Regions that experience -15˚F, 5-10 percent of the time in a 30-year period are suitable for the most tender cultivars. Regions that experience -15˚F, 10-15 percent of the time are suitable for moderately cold-hardy hybrid cultivars. The majority of the inner Bluegrass and the Bluegrass regions fall within this designation. Regions that experience -15˚F more than 20 percent of the time in a 30-year period include Campbell and Pendleton counties. In these counties only cold-hardy cultivars are recommended for commercial viticulture.

Winter Severity Index (WSI)

Another limiting factor for grape production is winter severity. In very continental areas, such as central Europe, Asia, or North America, midwinter temperatures can be cold enough to kill or seriously damage the grapevines. Damage and death can occur in French-American and native grapevines if the winter temperature falls below 5˚F. The WSI is the mean temperature of the coldest month (January) in any given 30-year period. If the WSI is <5˚F then the winters are extremely cold (Figure 2). If the WSI is

between 5˚F and 14˚F, the winters are very cold; if between 14˚F and 23˚F, the winters are cold; and if between 23˚F and 32˚F, the winters are mildly cold. In western Kentucky, the winters can be characterized as cold to very cold. However, the regions around Daviess County are characterized as having mildly cold winters (Figure 2). In central Kentucky, the winters are cold with regions of mildly cold winters occurring in and around Shelby County. The Bluegrass region is characterized as having extremely cold winters, and so is eastern Kentucky with very cold winters occurring in southeastern Kentucky.

Figure 1. Occurrence of -15ºF (percent of time, 1974-2005).

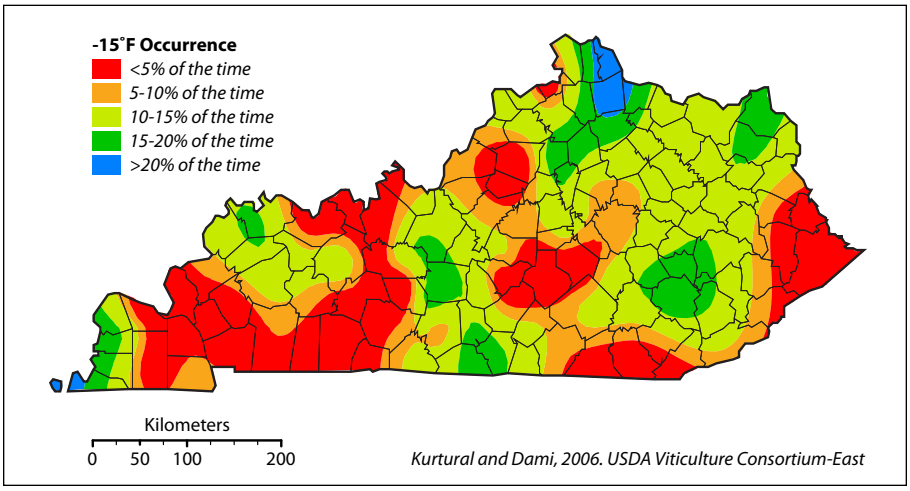
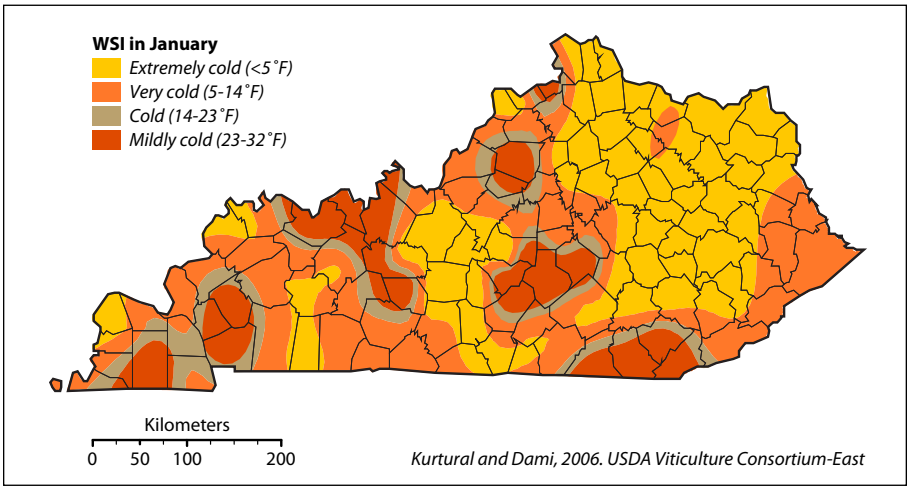


Figure 2. Winter severity index (WSI) in January (1974-2005).



Beginning of the Growing Season

Spring Frost Index (SFI)

Grapevine buds can be injured either by early fall or late spring frosts. Frost, for the purposes of this bulletin, is described as occurring when the buds are fully swollen, or when the leaves are unfolded (Figure 3a). Spring frosts can injure some vineyards and are more frequent in some parts of the state than in others. Historically, the Commonwealth experiences a January-thaw that reduces acclimation, followed by more seasonable damaging low temperatures. Grape shoots are very susceptible to freeze injury if temperatures are below 32˚F (Figure 3b). Spring frosts generally do not kill vines because secondary buds will subsequently break and their shoots will provide enough leaf area to support the vine; however, secondary buds produce shoots that are less fruitful.

One method of evaluating a site's risk of frost is based on the range between a site's average mean and average minimum temperatures for a given month. This range is defined for spring months as a "spring frost index" (SFI) and is a measure of a site's continentality, or tendency to produce large fluctuations in temperature over short periods of time. Bud break is influenced by air temperature, and grapevines tend to break bud early if temperatures warm up quickly in early spring. April is the month in which grape growers face the most damage from spring frosts. April SFI indices are shown in Figure 4. SFI values less than 11.0 have relatively low frost risk, whereas those of 13.0 or greater are high risk. Eastern portions of Kentucky have a high likelihood of experiencing spring frost events. There is moderate frost risk in northern, north-central, central, and western Kentucky. Low frost risk is mostly found in the central region of Kentucky and also in western Kentucky. Although the SFI applies to spring frost, the same technique is used to gauge a site's risk of fall frost in October. There is a strong correlation between spring and fall frost risk in Kentucky.

Figure 3a. Swollen grape buds and unfolded leaves are susceptible to spring frost injury.

Figure 3b. New shoots are susceptible to freeze injury if temperatures are below 32ºF.

Growing Season

Growing Degree Days (GDD)

Grape growing regions based on Growing Degree Days are presented in Table 2 and Figure 5. The GDD summation between 1 April and 31 October is used to predict the grapevine's ability to mature a high quality crop in the northern hemisphere. Vineyard suitability must adhere to baseline heat unit accumulation to ensure sufficient crop maturity. The Amerine and Winkler GDD summation divides a given area into five regions based on the GDD summation. Region I is characterized as areas accumulating less than 2500˚F, region II accumulating between 2501˚F and 3000˚F GDD, region III between 3001˚F to 3500˚F GDD, region IV between 3501˚F GDD to 4000˚F GDD, and region V more than 4000˚F GDD. In Kentucky, there are no areas of the state that fall within the Region I or Region II window (Figure 5). Eastern Kentucky falls into Region III (Figure 5). For this region, high yields of standard to good quality table wines are to be expected. The majority of the Bluegrass Region, southern Kentucky, and portions of western Kentucky fall into the Region IV designation. In these areas high yield and acceptable wine quality are expected with the suitable cultivars. The majority of western Kentucky falls within the Region V designation.

Frost-free Days (FFD)

The length of the growing season (FFD), however, is more limiting to viticulture than GDD accumulation. The FFD actually determines ecological boundaries of sustainable viticulture. The majority of the state has more than 180 FFD, which is deemed "Excellent" to grow the majority of the cultivars recommended for the Midwest (Figure 6). Portions of central Kentucky, however, have between 171 and 180 FFD. This corresponds to a "Good" designation, and indicates that early, mid-season, and some late-season cultivars for the Midwest can be grown successfully (Figure 6). Portions of northern Kentucky and a number of eastern counties have 160 to 170 FFD, which is deemed "Satisfactory". For these regions, early and most mid-season maturing cultivars are recommended.

Figure 4. Spring frost index (SFI) in April (1974-2005).

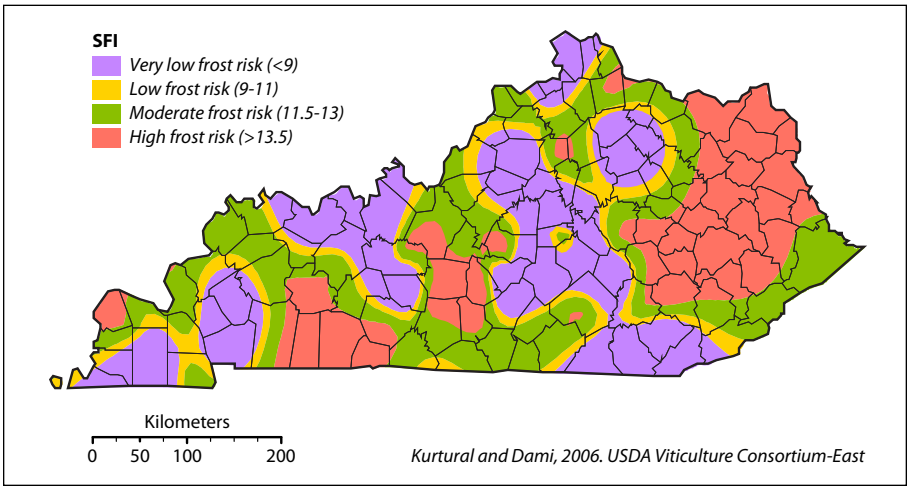


Figure 5. Growing degree day accumulation means at 50ºF base, no upper limit (1974-2005).

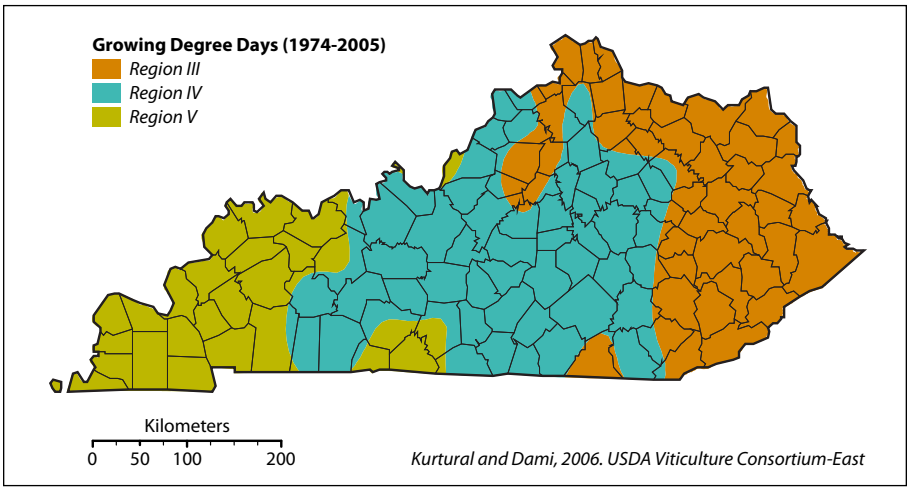


Table 2. Grape growing regions based on Growing Degree Days.

Region	Growing Degree Days	Adapted cultivars and wine quality
I	≤2,500	Early ripening cultivars to achieve high quality
II	2,501 – 3000	Early and mid-season table wine cultivars
III	3,001 – 3,500	High yield of standard to good quality wines
IV	3,501 – 4000	High yield, but wine quality is only acceptable
V	≥ 4000	High production of late season wine and table cultivars for bulk production

Source: Amerine and Winkler, 1944.

Growing Season Mean Temperature

It is not yet fully understood why cooler climates generally produce the best quality table wines, but evidence suggests that lower temperatures during the growing season are of special significance. In warmer climates, ripening of grapes occurs early, when the weather is still warm or even hot. These hot conditions cause rapid development of sugars, rapid loss of acids, and high pH levels. The juice is often unbalanced with respect to sugar, acid, and pH, and the grapes appear to have had insufficient time to

accumulate many chemical compounds that add distinction to the wine. A cooler growing season–often with considerable diurnal temperature variation–slows down development; better balances are achieved, and more aroma and flavor constituents are accumulated. Growing season mean temperature varies considerably in Kentucky (Figure 7). The coolest, therefore the most desirable, growing season exists in isolated areas of southwestern, western, central, and south-central Kentucky. The majority of the regions in Kentucky fall within the warm and hot growing season designation, especially in the central and Bluegrass regions of Kentucky.

Climate Suitability and Viticultural Regions in Kentucky

Overall, the quality of wine produced in any region comes primarily from the high quality of the grapes that are carefully vinified thorough long-held practices in the winery. The quality of the grape, however, is the result of the combination of climate, site, geology, choice of grape cultivar, and how these are all managed to produce the best crop. The macroclimatic properties of the viticultural regions in Kentucky are presented in Table 3 and Figure 8. There are five distinct growing regions in Kentucky ranging from Region I (prime) to Region V (undesirable). Region I would lend itself to the production of premier grapes; in Region V grape growing itself would be a challenge. The summary of commercial grapes suitable for planting in Kentucky within these regions is presented in Table 4, based on the macroclimate analysis of the state. However, prospective growers need to contact local county Extension offices for mesoclimate site analysis through the Kentucky Grape Planting Spatial Decision Support System before planting vineyards.

Note: This work was supported in part by the USDA-Viticulture Consortium East.

Figure 6. Frost free days, means (1974-2005).

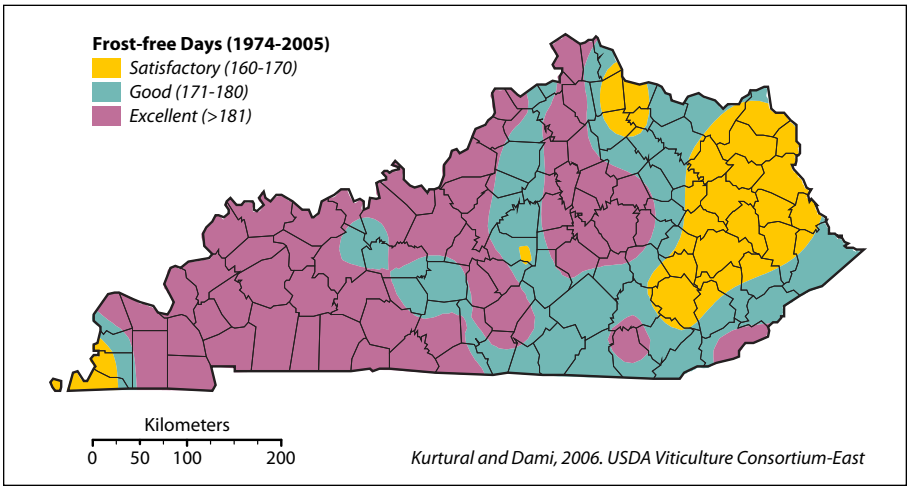


Figure 7. Growing season mean temperature from 1 April to 31 October (1974-2005).

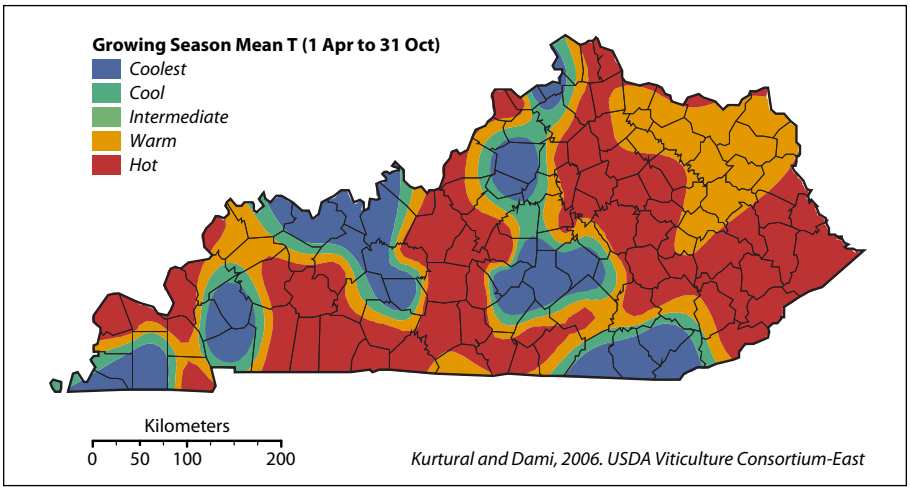


Table 3. Ranking of macroclimatic regions in Kentucky for viticulture.

	Region I	Region II	Region III	Region IV	Region V
Occurrence of -15°F[a]	<5%	5%-10%	10%-15%	15%-20%	>20%
Winter severity index[b]	Mildly cold	Cold	Very cold	Extremely cold	Extremely cold
Spring frost index[c]	<9	9-11	11.5-13	11.5-13	>13.5
Growing degree days[d]	Region III/IV	Region III/IV	Region IV	Region IV	Region V
Frost free days[e]	>181d	>181d	171-180d	160-170d	160-170d
Growing season mean temperature[f]	Coolest	Cool	Intermediate	Warm	Hot

[a] Occurrence of -15°F percent of the time between 1974-2005.
[b] Mean temperature of January between 1974-2005. Extremely cold <5°F, Very cold 5°F to 14°F, Cold 14°F to 23°F, Mildly cold 23°F to 32°F.
[c] Spring frost index (SFI) for April: Difference between average mean and average minimum for the month of April between 1974-2005.
[d] Growing degree days calculated using 50°F base temperature between 1 April and 30 October 1974-2005.
[e] Days between last spring frost occurrence at 32°F and first fall frost occurrence at 32°F between 1974-2005.
[f] Growing season mean temperature is calculated as the mean of daily maximum temperatures between 1 April and 30 October 1974-2005.

Figure 8. Viticultural regions of Kentucky.

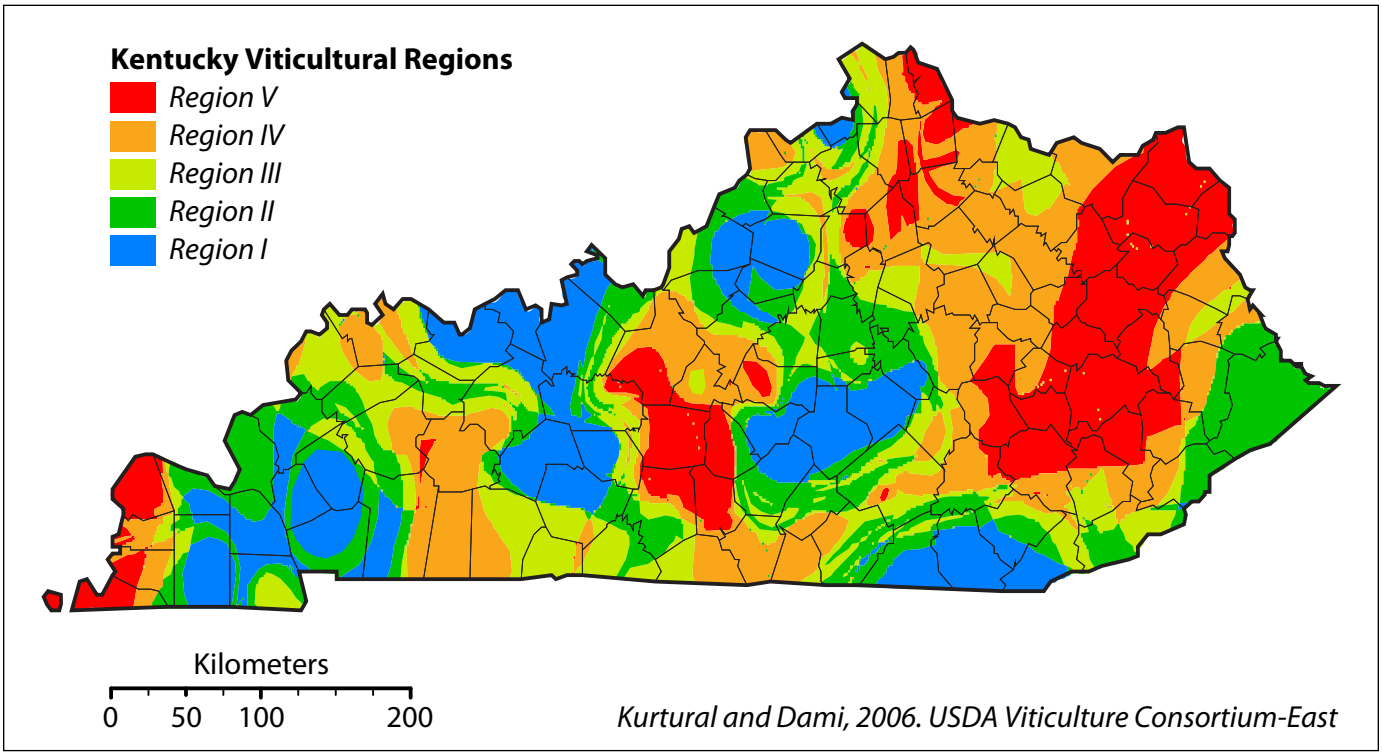


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Table 4. Summary of commercial grapes cultivars suitable for planting in Kentucky based on macroclimatic regions.

Cultivar	Region I	Region II	Region III	Region IV	Region V
Vinifera	None	None	None	None	None
Hybrid reds	Chambourcin Chancellor Corot Noir Noiret	Chancellor Corot Noir GR-7M Noiret St. Croix St. Vincent	Chancellor DeChaunac GR-7M Frontenac Leon Millot Marechal Foch Marquette St. Croix St. Vincent	DeChaunac GR-7M Frontenac Leon Millot Marechal Foch Marquette St. Croix St. Vincent	Frontenac Leon Millot Marechal Foch Marquette St. Croix St. Vincent
Hybrid whites	Cayuga white Chardonel Seyval blanc Traminette Valvin Muscat Vidal blanc Vignoles	Cayuga white Frontenac gris Seyval blanc Valvin Muscat Vidal blanc Vignoles	Frontenac gris LaCrescent LaCrosse Seyval blanc Vignoles	Frontenac gris LaCrescent LaCrosse Seyval blanc	Edelweiss Frontenac gris LaCrescent LaCrosse
American reds	Alden Catawba Delaware Norton	Alden Catawba Delaware Fredonia Norton	Alden Catawba Delaware Fredonia	Alden Catawba Delaware Fredonia Steuben	Alden Catawba Delaware Fredonia Steuben
American whites	Niagara	Niagara	Niagara	Niagara	Niagara

Issued 1-2008