

# Petition for Establishment of an American Viticultural Area Crest of the Blue Ridge Henderson County 

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# Petition for Establishment of an American Viticultural Area 

Crest of the Blue Ridge Henderson County

## 1) Introduction

Long renowned for its prolific apple and cider production, Henderson County, North Carolina is now the center of a burgeoning grape and wine industry. With eight active vineyards, almost 70 acres under grape cultivation and two bonded wineries, the local operators wish to have a portion of the county designated as an American Viticultural Area under the regulations of the US Dept. of the Treasury's Tax and Trade Bureau. The proposed name of the AVA is 'Crest of the Blue Ridge Henderson County,' named after the most important physiographic feature that trends through the county and through the proposed AVA.

Henderson County is located in the southwestern part of North Carolina (Figure 1). It is bounded on the north by Buncombe County, on the east by Rutherford and Polk Counties, on the west by Transylvania County, and on the south by Greenville County, SC. Hendersonville, the county seat of Henderson County, is the largest community within the proposed AVA and the center of apple production in North Carolina (Figure 2). The town of Flat Rock, also within the AVA, is the location of the Carl Sandburg National Historic Site, the last home of the famed poet, historian and folk singer. Asheville, NC, the county seat of Buncombe County, and the largest city of western North Carolina, lies 22 miles northwest of the center of the proposed AVA.

The area of the AVA is approximately 137,683 acres or 215 square miles. Elevations range from 1394 feet to 4396 feet, with a mean elevation of 2362 feet. The northwestern slope of the AVA, which descends from the Blue Ridge crest into the valley of the French Broad River, is part of the Blue Ridge Plateau, an uplifted, peneplain with broad valleys scattered among moderately high to high, residual mountains. On the east and south side of the Blue Ridge crest the terrain comprises narrow, deeplyentrenched valleys surrounded by rugged mountains. This area is known as the Blue Ridge Escarpment, the mountain front that rises precipitously from the low, rolling hills of the Inner Piedmont.

The proposed AVA has significant environmental differences that distinguish it from surrounding terrains to the north, east, south, and west. Major distinctions are related to elevation, which affects temperatures, length of growing season and precipitation, all of which lead to differences in the types of grapes that can be grown in the AVA and surrounding comparison areas. To the east and south of the AVA lie the low, rolling hills of the Inner Piedmont, where mean temperatures are higher, precipitation is lower and growing season is longer than in the AVA. Terrain north of the AVA is divisible into two distinct geomorphic regions: the Asheville Basin, a low-lying peneplain occupied by the valley of the French Broad River and the surrounding mountains, which we have informally designated as the 'north-highlands.' The Asheville Basin is markedly drier than the AVA with one of the lowest annual precipitation rates in the eastern United States. The north-highlands rise in elevation and culminate in the Black Range, which is capped by Mount Mitchell, the highest peak of the entire Appalachian chain and the highest point east of the Mississippi River. In the north-highlands elevation is higher, temperatures are lower and growing season is shorter than the AVA. Terrain west of the AVA ascends into the rugged mountains of the Pisgah National Forest, where annual

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Figure 1. Location of the proposed AVA in Henderson County, North Carolina.


Figure 2. Cities, towns and smaller communities within and surrounding the proposed AVA.
precipitation reaches some of highest rates in the eastern United States, temperatures are cooler, and growing season is shorter.

Boundaries of the proposed AVA have been drawn as far as possible along natural features that enclose all of the county's viticultural activities. Presently there are 13 active vineyards, belonging to nine operators, with 69.86 acres planted in Vitus vinifera, French-American hybrids and native American grape varieties. Vinifera varieties are by far the dominant grapes with $78 \%$ of total plantings. Vineyard operators estimate that they will plant an additional 55 acres in the next five years, and the great majority of these plantings will be vinifera grapes.

The proposed AVA has active and growing viticultural activity, a unique geographic setting along the Eastern Continental Divide, a name that uniquely describes this setting, and environmental characteristics that distinguish it from surrounding terrains. This petition documents these features and presents our case for approval of the Crest of the Blue Ridge Henderson County American Viticultural Area.

## 2) Name Evidence

The term 'Crest of the Blue Ridge' was first used by Col. Joseph Pratt, chief of the North Carolina Geological and Economic Survey from 1906-1923. In 1910 Pratt proposed the development of a scenic road and chain of tourist hotels atop or adjacent to the summit of the Blue Ridge, the continuous trend of peaks and ridges that forms the front of the eastern Appalachian chain. Pratt named this development 'Crest of the Blue Ridge Highway.' Several small sections of the road were built, but outbreak of the First World War interrupted the work and completion was put on hold. ${ }^{2,3}$ In the end Pratt's project was never completed, but the term 'Crest of the Blue Ridge' survived and remains in extensive use to describe areas of the Southern Appalachians, especially in North Carolina. That the geomorphic feature occurs in Henderson County and that the term is in widespread, present-day usage there is evidenced by U. S. Geological Survey topographic maps, and publications, references, and websites about the county, and its local attractions and events. A Wikipedia article ${ }^{4}$ describing the geographic setting of Henderson County states that "The Eastern Continental Divide, which lies along the crest of the Blue Ridge, passes through the county." Conservationist and author Peter Barr, in describing the Eastern Continental Divide in the county, ${ }^{5}$ states that "The Divide runs atop the crest of the Blue Ridge Escarpment, the dramatic wall formed by the land that rises abruptly from the Piedmont plateau to the high elevations of the southern Appalachians."

Reference to the nine U. S. Geological Survey 1:24,000-scale topographic maps that cover the proposed AVA ${ }^{6}$ (Figure 3) confirms that the Blue Ridge crest is present in Henderson County. On these maps the Blue Ridge is shown as a dashed line across the summit of adjacent mountain tops and gaps that are located along the east side of the proposed AVA. The name 'Blue Ridge' is labeled prominently along this dashed line. Looking further afield at USGS maps of areas north and south of

[^0]Henderson County confirms that the Blue Ridge crest forms the Eastern Continental Divide in an area extending from southern Virginia through North Carolina to Young Lick Mountain in northern Georgia. This prominent continental divide separates drainage to the Atlantic from drainage to the Gulf of Mexico and forms unique environmental areas along its trend.

In Henderson County, for example, a prominent topographic feature - called the Hendersonville Bulge ${ }^{7}$ - occurs along the east side of the county. Within the Bulge area the Crest of the Blue Ridge drops in elevation significantly from its altitudes to the north and south and bulges out to the east from its usual northeast-southwest orientation, forming a terrain of intermediate-elevation whose climatic characteristics differ greatly from those of its surroundings. This geomorphic situation has created the ideal environment for the commercial cultivation of fruits, especially for apples, which are the county's most important agricultural crop. Due to its unique setting, Henderson County is, in fact, the southernmost area in the eastern United States for large-scale, commercial apple cultivation. The term 'Crest of the Blue Ridge Agricultural Area' is used locally for this unique environmental region straddling the continental divide. The setting has been described as follows in a Wikipedia article:

> Henderson County's topographic and climatic diversity make it ideal for a great variety of commercial crops and agricultural products. Parts of the county between the Pisgah National Forest on the northwest and the boundary with Polk County on the southeast are often referred to as the Crest of the Blue Ridge Agricultural Area in recognition of the region's unique growing conditions. With the exception of tropical fruits and vegetables, local farmers and other agricultural professionals will tell you that almost any commercial crop will grow in Henderson County. ${ }^{8}$

A web publication of the Henderson County Tourism Development Authority describes the attractions and annual events occurring around Hendersonville and prominently advertises that the city is within the Crest of the Blue Ridge Agricultural Area. ${ }^{9}$

Another publication of the county's Tourism Development Authority - "Crest of the Blue Ridge Orchard Trail" - is a guide to seventeen commercial orchards that offer retail sales, 'pick-your-own' and tours of some of the nation's finest apple producers. ${ }^{10}$ Significantly, all seventeen of the orchards included on the trail are located entirely within the area of the proposed AVA.

The Tourism Development Authority's "Cheers Trail" publication advertises nine commercial breweries, cideries and wineries in Henderson County that produce beverages from fruits grown in local orchards and vineyards. ${ }^{11}$ The guide states that "All producers are located in Henderson County in the Crest of the Blue Ridge Agricultural Area."

The same climatic conditions that make commercial apple production so successful on Henderson County's Crest of the Blue Ridge slopes are also ideal for cultivation of V. vinifera and French-American

[^1]hybrid varieties of wine grapes. Several of the commercial grape growers have vineyards on both slopes of the Blue Ridge crest and have described the uniqueness of their settings on their websites:

Burntshirt Vineyards occupies a unique position with two vineyards on both sides of the Eastern Continental Divide on the Crest of the Blue Ridge - at some of the highest elevations on the east coast. ${ }^{12}$

The winery and tasting room [of St. Paul Mountain Vineyards] on Chestnut Gap Road includes a walnut bar, indoor seating and an outdoor patio only a few steps from Ward's [The reference here is to Mr. Alan Ward, the owner and operator of the vineyards] five acres of grape vines. Besides that vineyard, at 2300 feet, Ward and another grower cultivate another 10 acres of grapes at 3000 -foot Point Lookout on the crest of the Blue Ridge in Edneyville. The elevation, lower in humidity and early morning drying of the grapes on the mountain slopes makes a far better growing season than many vineyards in the more established Yadkin Valley region of North Carolina. ${ }^{13}$

In addition to apples and grapes other crops are grown in Henderson County's Crest of the Blue Ridge Agricultural Area. Agribusiness Henderson County, a local non-profit agriculture and agri-tourism advocate, promotes the county's 38,000 acres of farm businesses through its Southern Mountain Fresh brand. The organization describes its goal as follows:

Southern Mountain Fresh is the official brand for Henderson County's bounty of farm products. Our goal is to make it easy to identify truly local produce, craft beverages, plants and other commodities. Enjoy the freshness of the Crest of the Blue Ridge mountains and sustain our agricultural heritage. ${ }^{14}$

The Crest of the Blue Ridge is an important geomorphic feature in Henderson County, as well as a locally recognized agricultural setting with unique growing characteristics. That the feature passes through the proposed AVA is well documented by USGS maps and by references on various websites and in publications that describe the county's geographic setting, attractions and events. The term "Crest of the Blue Ridge" is widely applied to Henderson County at present and is the name that the local vineyard operators have unanimously chosen for their proposed AVA. The operators are aware that the term 'Crest of the Blue Ridge' has been applied to a broader geographic area than Henderson County, and to avoid confusion about the location of the AVA they propose the addition of the geographic delimiter 'Henderson County' to the term 'Crest of the Blue Ridge.' The final proposed name of the AVA is, therefore, 'Crest of the Blue Ridge Henderson County.'

## 3) Boundary Description

The boundaries of the proposed AVA are located entirely within Henderson County on nine US Geological Survey 1:24,000-scale topographic maps (Table 1 and Figure 3). The boundary begins on Little Pisgah Mountain at the south end of the Black Mountain, NC map and proceeds clockwise through the Bat Cave, Cliffield Mountain, Saluda, Zirconia, Standingstone Mountain, Horse Shoe, Hendersonville, and Fruitland quadrangle maps. The approximate distances between each segment are straight line distances between beginning and ending points.

[^2]| Quadrangle Sheet Name | Map <br> Scale | Map <br> Date | Revision <br> Date | Mapped By | Published By |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Bat Cave, NC | $1: 24,000$ | 1997 | 2000 | USGS, TVA | USGS |
| Black Mountain, NC | $1: 24,000$ | 1941 | 1978 | TVA | USGS |
| Cliffield Mountain, NC | $1: 24,000$ | 1997 | 2000 | USGS, TVA | USGS |
| Fruitland, NC | $1: 24,000$ | 1997 |  | USGS, TVA | USGS |
| Hendersonville, NC | $1: 24,000$ | 1997 | 2000 | USGS, TVA | USGS |
| Horse Shoe, NC | $1: 24,000$ | 1965 | 1991 | TVA | USGS |
| Saluda, NC, SC | $1: 24,000$ | 1983 |  | USGS, NCGS, NCDOT | USGS |
| Standingstone Mountain, NC, SC | $1: 24,000$ | 1965 | 1990 | TVA | USGS |
| Zirconia, NC, SC | $1: 24,000$ | 1946 | 1991 | USGS, TVA | USGS |

Table 1. USGS topographic maps that cover the proposed AVA

- Beginning at the 4412-foot elevation marker atop Little Pisgah Mountain (Point \#1, Black Mountain Quadrangle), proceed southeast along the boundary between Buncombe and Henderson Counties to the intersection of the boundaries between Buncombe, Henderson and Rutherford counties (Point \#2, Bat Cave Quadrangle). Approx. distance 4.4 miles.
- Proceed south along the boundary between Henderson and Rutherford Counties to the intersection of the boundaries between Rutherford, Henderson and Polk Counties (Point \#3, Bat Cave Quadrangle). Approx. distance 5.1 miles.
- Proceed southwest along the boundary between Henderson and Polk Counties to the intersection of the boundary with the border between North Carolina and South Carolina (Point \#4, Saluda Quadrangle). Approx. distance 14.9 miles.
- Proceed west along the boundary between Henderson County, NC and Greenville County, SC to the 3058 -foot elevation marker atop Big Top Mountain (Point \#5, Zirconia Quadrangle). Approx. distance 8.1 miles.
- Proceed northwest in a straight line from Big Top to the center of the highest closing contour atop Maybin Mountain (Point \#6, Standingstone Mountain Quadrangle). Approx. distance 2.0 miles.
- Proceed northeast in a straight line to the intersection of an unnamed road running parallel to Bell Creek (Shown as County Road 1113 on Google Earth) with Mountain Valley Road (Point \#7, Zirconia Quadrangle). Approx. distance 2.2 miles.
- Proceed northwest along Mountain Valley Road to its intersection with Pinnacle Mountain Road (Point \#8, Standingstone Mountain Quadrangle). Approx. distance 1.3 miles.
- At intersection proceed northwest along a straight line to the intersection of Little Cove Creek with the 2800-foot topographic contour (Point \#9, Standingstone Mountain Quadrangle). Approx. distance 1.0 mile.
- Follow the 2800 -foot contour westward to its intersection with the unnamed creek on the north slope of Stone Mountain that flows north into Jeffers Lake (Point \#10, Standingstone Mountain Quadrangle). Approx. distance 2.4 miles.
- Proceed in a straight line northwest to the point atop Hickory Mountain at which the boundary between Henderson and Transylvania Counties changes from a northwest to a northeast trend (Point \#11, Standingstone Mountain Quadrangle). Approx. distance 2.0 miles.
- Proceed northeast along the Henderson-Transylvania boundary to the point on the hilltop above the Sentell Cemetery at which the Henderson-Transylvania boundary makes an abrupt turn to the northwest (Point \#12, Horse Shoe Quadrangle). Approx. distance 2.6 miles.
- At the point of the abrupt turn proceed in a straight line northeast to the center of the highest closing contour atop Jeter Mountain (Point \#13, Horse Shoe Quadrangle). Approx. distance 1.6 miles.


Figure 3. Proposed AVA boundaries and boundary waypoints.

- Proceed in a straight line southeast to the center of the highest closing contour atop Evans Mountain (Point \#14, Horse Shoe Quadrangle). Approx. distance 1.3 miles.
- Proceed in a straight line northeast to the center of the highest closing contour atop Wolf Mountain (Point \#15, Horse Shoe Quadrangle). Approx. distance 2.0 miles.
- Proceed in a straight line northeast to the center of the highest closing contour atop Drake Mountain (Point \#16, Horse Shoe Quadrangle). Approx. distance 1.2 miles.
- Proceed in a straight line northwest to the center of the highest closing contour atop Cantrell Mountain (Point \#17, Horse Shoe Quadrangle). Approx. distance 0.7 miles.
- Proceed in a straight line northeast to the 2618-foot elevation marker on the northeast slope of Long John Mountain (Point \#18, Horse Shoe Mountain). Approx. distance 3.3 miles.
- Proceed northeast in a straight line to the center of the highest closing contour atop Stoney Mountain (Point \#19, Hendersonville Quadrangle). Approx. distance 1.4 miles.
- Proceed northeast in a straight line to the intersection of Brookside Camp Road with Dixie Highway (Point \#20, Hendersonville Quadrangle). Approx. distance 0.6 miles.
- Proceed northeast along Brookside Camp Road to its intersection with Locust Grove Road (Point \#21, Fruitland Quadrangle). Approx. distance 2.1 miles.
- Proceed northeast along Locust Grove Road to the Locust Grove Church (Point \#22, Fruitland Quadrangle). Approx. distance 1.4 miles.
- From the Locust Grove Church proceed northeast in a straight line to the 3442-foot elevation marker atop Rich Mountain (Point \#23, Fruitland Quadrangle). Approx. distance 0.7 miles.
- Proceed northwest in a straight line to the intersection of Souther Leveston Road with an unnamed jeep trail (Point \#24, Fruitland Quadrangle). Approx. distance 0.4 miles.
- Proceed northwest along Souther Leveston Road to its intersection with Hoopers Creek Road (Point \#25, Fruitland Quadrangle). Approx. distance 2.4 miles.
- Proceed northeast in a straight line to the 2983-foot elevation marker, named Edneyville-5, atop a peak on Burney Mountain and on the boundary between Henderson and Buncombe Counties (Point \#26, Fruitland Quadrangle). Approx. distance 0.7 miles.
- Proceed northeast along the boundary between Henderson and Buncombe Counties to the starting point atop Little Pisgah Mountain (Point \#1, Black Mountain Quadrangle). Approx. distance 8.2 miles.

4) Viticulture

At the present time there are 14 active vineyards and two bonded wineries belonging to nine operators in the proposed AVA (Figure 5 and Table 2). A total of 69.86 acres are under cultivation with 23 varieties of grapes (Table 3), including Vitis vinifera ( 54.25 acres), French-American hybrids ( 12.48 acres), and American types ( 3.13 acres). The predominant vinifera varieties include Cabernet Sauvignon, Cabernet Franc, Chardonnay, Grüner Veltliner, Riesling and Merlot. Lesser vinifera varieties include Petit Verdot, Sauvignon Blanc, Lemberger, Malbec, Petit Manseng, Dornfelder, and Pinotage. The predominant French-American hybrid grape is Vidal Blanc. Other hybrid grapes include Traminette, Chambourcin, Chardonnel, Baco Noir, and Léon Millot. Norton-Christiana, Catawba and Fredonia are the three American varieties presently under cultivation.

The oldest commercial vineyard in the AVA is Saint Paul Mountain, which was planted in 2007 and presently has 18.25 acres under cultivation. Burntshirt, planted in 2008, is the second oldest and largest with 27.00 acres in vines. Both St. Paul Mountain and Burntshirt have bonded wineries. Three of the other vineyards (Souther WIliams Mountain, Green Mountain, and Marked Tree) will eventually


Figure 4. Location of vineyards. Active vineyards shown in purple, inactive in green.

| Vineyards | Number <br> of Sites | Owners | Owner's Address | City/State | Zip <br> Code |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Arrowhead Vineyards | 1 | Hubert Boeck | 715 Mergans Ln. | Hendersonville, NC | 28791 |
| Burntshirt Vineyards** | 2 |  <br> Sandra Oates | 3737 Howard Gap Rd. | Hendersonville, NC | 28792 |
| Cabin Creek Vineyards | 4 | Alan Staton | 1150 Terry's Creek Rd. | Zirconia, NC | 28790 |
| Dolce Vita Vineyards | 1 | Albert Finn | 50 Water Turkey <br> Retreat | Charleston, SC | 29412 |
| Green Mountain <br> Vineyards | 1 | Dr. Craig Little | 403 A W. 4th N. St. | Summerville, SC | 29483 |
| Marked Tree Vineyards | 1 | Lance Hiatt, <br> Tim Parker | 193 Haywain Drive | Chapin, SC | 29036 |
| Saint Paul Mountain <br> Vineyards** | 2 | Alan Ward | 588 Chestnut Gap Rd. | Hendersonville, NC | 28792 |
| Souther Williams <br> Mountain Vineyards | 1 | Kenneth <br> Parker | 655 Hoopers Creek Rd. | Fletcher, NC | 28732 |
| Stepp's Hillcrest Orchards | 1 | Mike Stepp | 170 Stepp Orchard Dr. | Hendersonville, NC | 28792 |

Table 2. Vineyard operators and addresses. ** indicates vineyard has a bonded winery.
have wineries but their plantings are young and not yet ready for wine production. Six of the present operators anticipate adding a total of 55 additional acres to their vineyards in the next five years. The majority of the future plantings will be vinifera.

Up until 2016 there were two other vineyards in the area of the AVA - Bella Rooster and Judd's Peak. Due to the owners' ages and health problems these operations ceased in 2016, and the plantings have been cleared. Both vineyards were planted in vinifera grapes. The two defunct vineyards are shown on the map of vineyard locations (Figure 4), but are not included in the acreage statistics in Table 3.

## 5) Distinguishing Characteristics

The proposed AVA covers 215 square miles totally within Henderson County and straddles two physiographic provinces - The Blue Ridge Escarpment and the Blue Ridge Platepau, which are separated by the Eastern Continental Divide, or Crest of the Blue Ridge. The Blue Ridge Escarpment is the steep mountain front that rises precipitously from the low rolling hills of the Inner Piedmont and lies east and south of the continental divide. The Blue Ridge Plateau, a high, low-lying peneplain of broad valleys and residual peaks and ridges, extends north and west of the divide and forms the core of the southern Appalachians southward of Roanoke, Virginia. To analyze and discuss the characteristics of the proposed AVA that differentiate it from adjacent terrains we have analyzed environmental factors for twelve surrounding counties, divided into four comparison areas (Figure 5). In the following discussion we refer to the proposed AVA and the surrounding comparison areas as the 'study area.'

The north comparison area covers 1424 square miles and includes Buncombe, Yancey and Madison Counties in North Carolina. This terrain is part of the Blue Ridge Plateau and is divided for the

| Grape Varieties | Class |  | Vineyards and Acreages |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\begin{aligned} & \text { 嗞 } \\ & \stackrel{U}{U} \\ & \stackrel{C}{0} \\ & \text { © } \end{aligned}$ |  |  |  |  |  |  | Total Acreages |  |
| Baco Noir | Hybrid |  |  | 0.50 |  |  |  |  |  |  | 0.50 | 0.7\% |
| Cabernet Franc | V. vinifera | 1.33 | 2.50 | 0.50 |  |  | 1.00 | 4.00 |  |  | 9.33 | 13.4\% |
| Cabernet Sauvignon | V. vinifera | 1.33 | 3.40 |  | 0.25 | 2.00 |  | 3.00 |  |  | 9.98 | 14.3\% |
| Catawba | American |  |  | 1.00 |  |  |  |  |  |  | 1.00 | 1.4\% |
| Chambourcin | Hybrid |  | 1.00 |  |  |  |  |  |  |  | 1.00 | 1.4\% |
| Chardonnay | V. vinifera |  | 3.90 |  |  | 1.00 |  | 3.00 |  |  | 7.90 | 11.3\% |
| Chardonnel | Hybrid |  |  |  |  |  | 1.00 |  |  |  | 1.00 | 1.4\% |
| Dornfelder | V. vinifera |  |  | 0.25 |  |  |  |  |  |  | 0.25 | 0.4\% |
| Fredonia | American |  |  |  |  |  |  |  | 0.13 |  | 0.13 | 0.2\% |
| Grüner Veltliner | V . vinifera |  | 4.00 |  |  |  | 1.00 | 0.25 |  | 1.50 | 6.75 | 9.7\% |
| Léon Millot | Hybrid |  |  | 0.25 |  |  |  |  |  |  | 0.25 | 0.4\% |
| Lemberger | V. vinifera |  |  |  |  |  | 1.00 |  |  | 0.50 | 1.50 | 2.1\% |
| Merlot | V. vinifera | 1.34 | 2.90 |  |  |  |  | 2.00 |  |  | 6.24 | 8.9\% |
| Malbec | V. vinifera |  | 1.00 |  |  |  |  |  |  |  | 1.00 | 1.4\% |
| Norton-Christiana | American |  |  |  |  |  |  |  |  | 2.00 | 2.00 | 2.9\% |
| Petit Manseng | V. vinifera |  | 0.50 |  |  |  |  |  |  |  | 0.50 | 0.7\% |
| Petit Verdot | V , vinifera |  | 0.70 |  |  |  |  | 1.50 |  |  | 2.20 | 3.1\% |
| Pinotage | V. vinifera |  |  | 0.25 |  |  |  |  |  |  | 0.25 | 0.4\% |
| Riesiing | V. vinifera |  | 3.25 |  |  |  |  | 3.00 |  |  | 6.25 | 8.9\% |
| Sauvignon Blanc | V. vinifera |  |  |  |  | 2.10 |  |  |  |  | 2.10 | 3.0\% |
| Steuben | Hybric |  |  |  |  |  |  |  | 0.13 |  | 0.13 | 0.2\% |
| Traminette | Hybrid |  | 1.20 | 0.50 |  |  |  |  |  |  | 1.70 | 2.4\% |
| Vidal Blanc | Hybrid |  | 2.65 | 1.75 |  |  | 1.00 | 1.50 |  | 1.00 | 7.90 | 11.3\% |
| Total Acreage |  | 4.00 | 27.00 | 5.00 | 0.25 | 5.10 | 5.00 | 18.25 | 0.26 | 5.00 | 69.86 | 100.0\% |
| \% of Total Acreage |  | 5.7\% | 38.6\% | 7.2\% | 0.4\% | 7.3\% | 7.2\% | 26.1\% | 0.4\% | 7.2\% | 100.0\% |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| American |  |  |  | 1.00 |  |  |  |  | 0.13 | 2.00 | 3.13 | 4.5\% |
| Hybrid |  |  | 4.85 | 3.00 |  |  | 2.00 | 1.50 | 0.13 | 1.00 | 12.48 | 17.9\% |
| $\checkmark$ Vinifera |  | 4.00 | 22.15 | 1.00 | 0.25 | 5.10 | 3.00 | 16.75 |  | 2.00 | 54.25 | 77.6\% |
| Total Acreage |  | 4.00 | 27.00 | 5.00 | 0.25 | 5.10 | 5.00 | 18.25 | 0.26 | 5.00 | 69.86 | 100.0\% |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Estimated Future Planting (Next Five Years) |  |  |  |  |  |  |  |  |  |  |  |  |
| Total Acreage |  |  |  | 5.00 | 15.00 | 5.00 | 10.00 | 15.00 |  | 5.00 | 55.00 |  |

Table 3. Vineyards, grape varieties and acreages.


Figure 5. Location of proposed AVA, surrounding comparison areas, profile lines, Eastern Continental Divide/Crest of the Blue Ridge and Blue Ridge Escarpment.
purposes of our analysis and discussion into two markedly different geomorphic regions. The Asheville Basin, a low-lying peneplain occupied by the north-sloping valley of the French Broad River, is the lowest-elevation area of the north comparison area. Surrounding the basin on its east and west flanks are higher residual peaks and ranges that we refer to in this discussion as the 'north-highlands' area. The highest terrain of the north-highlands comprises the Black Mountain range, which includes Mount Mitchell, the highest peak of the Appalachian chain and the highest point east of the Mississippi River. Both of these features belong to the north comparison area, but because they are very different, we have analyzed them and compared them separately to the proposed AVA.

The east comparison area covers an area of 1250 square miles and includes McDowell, Rutherford and Polk Counties in North Carolina. The west edge of this area is in the Blue Ridge Escarpment, but most of the area is located within the Inner Piedmont, the peneplained plateau surface that lies east of the southern Appalachian front.

The south comparison area has an area of 2126 square miles and includes three counties in South Carolina: Pickens, Greenville, and Spartanburg. The northern rim of Pickens and Greenville Counties is located within the Blue Ridge Escarpment, while the rest of the areas are in the peneplained Inner Piedmont terrain.

The west comparison area covers 1588 square miles and includes Haywood, Jackson, and Transylvania counties and two small parts of the southwest side of Henderson County, all within North Carolina. The east side of the area falls within the French Broad River valley, while most of the area consists of high mountains and rugged terrain that are part of the Pisgah National Forest or belongs to conservation areas along the southwest side of Henderson County. The west comparison area that is located on the northwest side of the Blue Ridge crest is part of the Blue Ridge Plateau province, while the area on the southeast side of the crest is part of the Blue Ridge Escarpment.

The most important factors for viticulture in the AVA and comparison areas are elevation and climate, including temperatures, length of growing season and precipitation variations. Our analysis of elevation and geomorphic characteristics has utilized Digital Elevation Model data ${ }^{16}$ generated by the U. S. Geological Survey (USGS), and topographic maps produced by the USGS and downloaded from the Libre Map Project website. ${ }^{17}$ Climate analysis utilized the 1980-2010 interpolated climate normals generated by the PRISM Climate Group at Oregon State University. ${ }^{18}$ These datasets were analyzed, mapped and evaluated using ArcMap 10.4 software and the functionality of its Spatial Analyst extension. ${ }^{19}$

## A) Elevation

Elevation is a critical environmental characteristic for viticulture as it plays a major role in determining the climatic factors of temperature, length of growing season, and precipitation. In most mountainous areas of the world higher elevations tend to have lower temperatures, shorter growing seasons, and higher rates of precipitation than surrounding lower-elevation regions. In addition,

[^3]mountain fronts that rise abruptly from lower terrains often act as orographic barriers, producing rain shadow effects that cause high local precipitation and adjacent areas of low rainfall and drought. Each of these characteristics applies in the case of the proposed AVA.

Figure 6 is a Digital Elevation Model of the AVA and its surroundings. This view, plus the frequency distribution plot in Figure 7 and the three elevation profiles in Figures 8, 9 and 10, show clearly the differences in elevation between the proposed AVA and surrounding comparison areas. The frequency distribution plot compares the percentages of occurrence of elevations in all the terrains. The proposed AVA, and the Asheville basin to the north and the west comparison area all have the same range of modal elevation values (most commonly occurring value) of 2100-2200 feet, but the Asheville basin has a much more restricted total range of elevation, and a much higher percentage of the modal range (Table 4). The mountainous areas of the north comparison area have a modal value of 2600-2700 feet. The north and west areas have lower percentages of the modal elevation values and greater percentages of higher elevation terrain. In the elevation range 2100-2200 feet the percentage of occurrence in the AVA is 26.5 , while the percentages in the north-highlands and west areas are 13.3 and 15.4, respectively. In the elevation range 2900-3000 feet, the percentage of occurrence in the AVA is 2.5 , and in the north-mountains and west areas are 3.5 and 5.8 , respectively. Modal elevation values for the south and east comparison areas are much lower than those of the AVA, 1000-1100 feet for the south area and 900-1000 feet for the east area. The percentage of higher elevation terrain within the east and south comparison areas is also much lower than the proposed AVA.

To the east and south of the AVA the terrain descends precipitously to the lower elevation peneplain of the Inner Piedmont (Figures 8 and 9). To the north, the Asheville Basin descends northward from the west slope of the AVA along the valley of the French Broad River (Figure 9). The residual hills and mountains surrounding the Asheville Basin rise high above the peneplaind surface of the Blue Ridge Plateau to the greatest elevations of the entire Appalachian chain. Within the comparison areas the mean elevations of the east and south areas are 1150.9 feet and 1409.5 feet, respectively, compared to a mean elevation for the proposed AVA of 2361.8 feet (Table 4). To the north, the mean elevation of the Asheville basin is 2147.9 feet, while the mean elevation of the north-highlands is 3177.8 feet. Mean elevation of the west comparison area is 2769.9 feet.

| Comparison Areas | Elevation Parameters (Feet ASL) |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Minimum | Maximum | Mean | Modal Range |
| Proposed AVA | 1394.4 | 4396.3 | 2361.8 | $2100-2200$ |
| North-Asheville Basin | 1236.9 | 3284.1 | 2147.9 | $2100-2200$ |
| North-Highlands | 1305.8 | 6684.0 | 3177.8 | $2700-2800$ |
| East | 702.1 | 3966.5 | 1150.9 | $900-1000$ |
| South | 816.9 | 3631.9 | 1409.5 | $1000-1100$ |
| West | 1958.7 | 5715.2 | 2769.9 | $2100-2200$ |

Table 4. Comparison of elevation parameters.


[^4]

Figure 7. Frequency distribution of elevations in study area.


Figure 8. North-south profiles. See Figure 5 or Figure 6 for line location.


Figure 9. West-east profiles. See Figure 5 or Figure 6 for line location.


Figure 10. Northwest-southeast profiles. See Figure 5 or Figure 6 for line location.

To summarize, the AVA is considerably higher in elevation than the Asheville Basin and the comparison areas to the east and south, but is lower than the north-highlands and the west comparison area. These elevation differences account for many of the differences in the climate factors of temperature and precipitation, which are discussed in the following sections.

## B) Mean Annual Temperature

Temperature is a critical environmental factor for viticulture, since it determines the length of an area's growing season and the type of grapes that can best be cultivated there. Figure 11 illustrates mean annual temperatures in the study area. The total range of values is 44.6 to $61.9^{\circ} \mathrm{F}$. The proposed AVA has a significantly cooler mean annual temperature than the east and south areas and is slightly warmer than the Asheville Basin of the north area, and significantly warmer than the north Highlands and the west comparison area (Table 5). The relative differences in mean temperatures hold for each of the individual months and for the four seasons of the year. The three profiles shown in Figures 8 , 9 , and 10 demonstrate the direct relationship between temperature and elevation. In the NorthSouth, Northwest-Southeast and East-West profiles temperature decreases as elevation rises and increases as elevation descends. In the low elevation terrain of the Inner Piedmont mean annual temperatures are at their highest values, they cool rapidly as one ascends the Blue Ridge Escarpment and crosses the proposed AVA and continue to fall as one goes into the higher elevations of the north Highlands and the west comparison area (Figures 8 and 9). Temperatures in the Asheville Basin of the north comparison area vary slightly with that area's small elevation changes as one descends along the valley of the French Broad River, but the temperatures are generally lower than those of the proposed AVA (Figure 10).

To demonstrate how temperatures in the study area affect the suitable types of grapes in each terrain we have used three metrics: Average Growing Season Temperature, average length of growing season, and Growing Degree Days zonation.

| Comparison Areas | Mean Annual Temperatures ( ${ }^{\circ} \mathrm{F}$ ) |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Minimum | Maximum | Mean | Modal Range |
| Proposed AVA | 51.7 | 57.9 | 55.5 | $55-56$ |
| North-Asheville Basin | 52.5 | 57.3 | 55.2 | $55-56$ |
| North-Highlands | 44.6 | 55.4 | 52.5 | $52-53$ |
| East | 48.2 | 60.2 | 58.8 | $59-60$ |
| South | 53.7 | 61.9 | 59.0 | $60-61$ |
| West | 46.1 | 58.2 | 53.8 | $54-55$ |

Table 5. Comparison of mean annual temperature parameters.


Figure 11. Mean annual temperature distribution.

## C) Average Growing Season Temperature

In publications in $2006^{20}$ and $2012^{21}$ Prof. G. V. Jones of Southern Oregon University used Average Growing Season Temperature of important wine production areas of the world to classify grape varieties into four major 'Climate/Maturity Groupings' (Figure 12). We have calculated and mapped the average growing season temperatures of the study area terrains ${ }^{22}$ and have found that all four of Jones's groupings occur there, and that they form distinguishing characteristics of the AVA and surrounding comparison areas (Figure 13). Figure 14 is a frequency plot showing the percentage of temperature ranges that occur throughout the study area. The graph illustrates how distinctly different the north-highlands, and the east, south and west areas are from the proposed AVA. Each of the study area terrains has more than one Climate/Maturity Groupings located within it, nevertheless each terrain is dominated by one major grouping (Table 6). The AVA and the Asheville Basin fall mainly in the 'Warm' category, while the north-highlands and the west comparison area predominantly in the 'Intermediate' grouping, with a smaller percentage of 'Warm' areas. The west and north-highlands areas also have a small percentage of terrain in the 'Cool' grouping, but these areas are at elevations above 4800' and therefore subject to a high risk of severe winter weather conditions and are located mainly in National Forest lands or in Mount Mitchell State Park; they are not considered to be viable viticultural areas. The east and south comparison areas are predominately in the 'Hot' category.

| Comparison Areas | Winegrape Climate/Maturity Groupings |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Percentage of Occurrence in Each Area |  |  |  |
|  | Cool <br> $55-59^{\circ} \mathrm{F}$ | Intermediate <br> $59-63^{\circ} \mathrm{F}$ | Warm <br> $63-67^{\circ} \mathrm{F}$ | Hot <br> $67-72^{\circ} \mathrm{F}$ |
| AVA |  |  | 94.9 | 5.1 |
| North-Asheville Basin |  | 1.7 | 97.0 | 1.3 |
| North-Highlands | 4.0 | 66.7 | 29.3 |  |
| East |  | 4.9 | 13.4 | 81.7 |
| South |  |  | 3.8 | 96.2 |
| West | 5.6 |  | 36.5 | 0.7 |

Table 6. Distribution of Winegrape climate/maturity groupings.

[^5]
## Grapevine Climate/Maturity Groupings


$\square$ Length of rectangle indicates the estimated span of ripening for that varietal
Figure 12. Climate-maturity groupings based on average growing season temperatures. Horizontal bar represents the range of temperatures at which each variety is known to ripen and produce high to premium quality wine in the world's benchmark regions. Dashed line at the end of the bars indicates that some adjustments may occur as more data becomes available, but changes of more than $+/-0.4-0.8^{\circ} \mathrm{F}$ are highly unlikely. The figure and the research behind it are a work in progress and are used with permission of the author, Dr. Gregory Jones (Jones, 2006; Jones et al, 2012).


Figure 13. Average growing season temperature.


Figure 14. Frequency distribution of average growing season temperatures.

## D) Average Length of Growing Season

The average length of the growing season in a region is defined as the average number of days between the last $28^{\circ} \mathrm{F}$ temperature (the temperature at which plant tissue begins to freeze and die) in the spring and the first occurrence of that temperature in the fall. The importance of this metric is that it determines whether the season in a specific region is long enough to ripen wine grapes, and if it is, which varieties of grapes are most appropriate to be grown there. We have used the 1981-2010 climate normals from 34 National Climate Data Center (NCDC) weather monitoring stations (Table 7) to make our estimate. The NCDC has calculated the average number of days between the last spring and first fall occurrence of $28^{\circ} \mathrm{F}$ in each of these stations. By plotting the number of days against the elevation of the stations and fitting a curve to this plot, we have established a mathematical relationship (Figure 15) that can be used to interpolate and map the estimated length of the growing season for the entire study area (Figure 16). The analysis demonstrates differences that distinguish the proposed AVA from its surrounding terrains.

The range of growing season length for the study area is estimated to be $141-240+$ days. The longest estimated growing seasons occur in the south and east comparison areas, while the shortest growing seasons occur in the north-highlands and the west comparison area (Table 8). The proposed AVA and the Asheville Basin of the north comparison area have similar average growing season lengths, but the estimated range (minimum to maximum number of days) varies widely, with the proposed AVA having terrain in the shorter growing season range, qualifying it for early-ripening grape varieties that are not indicated in the Asheville Basin.

The College of Agriculture and Life Sciences at Cornell University and the Institute for the Application of Geospatial Technologies have published the following guidelines for making decisions on siting a new vineyard based on length of growing season: ${ }^{23}$

```
<160 days Sites not recommended, growing season too short to fully ripen wine grapes
>160 days Sites marginal-acceptable for earliest ripening varieties
>170 days Satisfactory sites
>180 days Good sites
>190 days Sites not limited by growing season
>200 days Sites better for longer season varieties of grapes
```

Based on these guidelines the estimated elevations at which the above growing season lengths would apply in the study area are as follows:

```
<160 days Above 5500'
>160 days below 5500' and above 4866'
>170 days Below 4866' and above 4229'
>180 days Below 4229' and above 3592'
>190 days Below 3592' and above 2955'
>200 days Below 2955'
```

[^6]| NCDC Weather Stations | State | NCDC Code | County | L.at | Long | Station Elev (Ft) | Growing <br> Season <br> (days) | Map Code See Fig. 15 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Anderson FAA APP | SC | USW00093846 | Anderson | 34.4978 | -82.7097 | 760 | 246 | 1 |
| ASHEVILLE | NC | USW00013872 | Buncombe | 36 | -83 | 2238 | 226 | 2 |
| ASHEVILLE AP | NC | USWO0003812 | Buncombe | 35.4319 | -82.5375 | 2117 | 213 | 3 |
| Bent Creek | NC | USC00310724 | Buncombe | 35.5044 | -82.5967 | 2110 | 188 | 4 |
| BLACK MTN 2 W | NC | USC00310843 | Buncombe | 35.6072 | -82.3594 | 2290 | 195 | 5 |
| Brevard | NC | USC00311055 | Transylvania | 35.2283 | -82.7358 | 2220 | 196 | 6 |
| Caesars Head | SC | USC00381256 | Greenville | 35.1072 | -82.6256 | 3200 | 216 | 7 |
| Canton 1 SW | NC | USC00311441 | Haywood | 35.5167 | -82.85 | 2662 | 201 | 8 |
| Celo 2 S | NC | USC00311624 | Yancey | 35.8297 | -82.1769 | 2680 | 197 | 9 |
| Chesnee 7 WSW | SC | USC00381625 | Spartanburg | 35.1108 | -81.9675 | 748 | 217 | 10 |
| Clayton 1 SW | GA | USC00091982 | Rabun | 34.8619 | -83.4064 | 1915 | 201 | 11 |
| Clemson Oconee Co AP | SC | USW00053850 | Oconee | 34.6719 | -82.8864 | 891 | 273 | 12 |
| Clemson Univ | SC | USC00381770 | Pickens | 34.6603 | -82.8236 | 824 | 239 | 13 |
| Cullowhee | NC | USC00312200 | Jackson | 35.3117 | -83.1747 | 2192 | 196 | 14 |
| Fletcher 2 NE | NC | USC00313101 | Buncombe | 35.45 | -82.4833 | 2190 | 204 | 15 |
| Forest City 6 SW | NC | USC00313150 | Rutherford | 35.2653 | -81.9311 | 990 | 236 | 16 |
| Franklin | NC | USC00313228 | Macon | 35.1792 | -83.3925 | 2095 | 189 | 17 |
| Greenville | SC | USW00013886 | Greenville | 34.884 | -82.221 | 960 | 252 | 18 |
| Greenville Downtown Airport | SC | USW00013886 | Greenville | 34.846 | -82.346 | 960 | 253 | 19 |
| Hendersonville 1 NE | NC | USC00313976 | Henderson | 35.3297 | -82.4492 | 2160 | 218 | 20 |
| Highlands | NC | USC00314055 | Macon | 35.0567 | -83.1983 | 3850 | 196 | 21 |
| Hot Springs | NC | USC00314260 | Madison | 35.895 | -82.8311 | 1396 | 219 | 22 |
| Lake Toxaway 2 SW | NC | USC00314788 | Transylvania | 35.1086 | -82.9608 | 3080 | 203 | 23 |
| Laurens | SC | USC00385017 | Laurens | 34.4989 | -82.0219 | 589 | 236 | 24 |
| Long Creek | SC | USC00385278 | Oconee | 34.7975 | -83.2675 | 1650 | 224 | 25 |
| Marshall | NC | USC00315356 | Madison | 35.8036 | -82.6658 | 2000 | 187 | 26 |
| Morganton | NC | USC00315838 | Burke | 35.7308 | -81.6717 | 1160 | 21.5 | 27 |
| Mt. Mitchell | NC | USC00315923 | Yancey | 35.7586 | -82.2711 | 6240 | 153 | 28 |
| Pickens | SC | USC00386831 | Pickens | 34.8814 | -82.7189 | 1162 | 229 | 29 |
| Pisgah 3 NE | NC | USC00316805 | Transylvania | 35.2719 | -82.6475 | 2190 | 202 | 30 |
| Shelby 2 NNE | NC | USC00317845 | Cleveland | 35.3144 | -81.5336 | 920 | 216 | 31 |
| Swannanoa 2 SSE | NC | USC00318448 | Buncombe | 35.5733 | -82.385 | 4320 | 197 | 32 |
| Tryon | NC | USC00318744 | Polk | 35.2058 | -82.2517 | 1200 | 255 | 33 |
| Waterville 2 | NC | USC00319123 | Haywood | 35.7742 | -83.0981 | 1440 | 232 | 34 |

Table 7. NCDC weather stations used to estimate length of growing season.


Figure 15. Graph of average growing season versus elevation, used to establish relationship to estimate length of growing season through the study area.


Figure 16. Estimated length of growing season.

Distribution of the estimated growing season length and of the Cornell University suitability zones are summarized in Tables 8 and 9.

| Comparison <br> Areas | Growing Season Length in Days |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & 140- \\ & 150 \end{aligned}$ | $\begin{aligned} & 150- \\ & 160 \end{aligned}$ | $\begin{gathered} 160- \\ 170 \end{gathered}$ | $\begin{aligned} & 170- \\ & 180 \end{aligned}$ | $\begin{gathered} 180- \\ 190 \end{gathered}$ | $\begin{aligned} & 190- \\ & 200 \end{aligned}$ | $\begin{aligned} & 200- \\ & 210 \end{aligned}$ | $\begin{aligned} & 210- \\ & 220 \end{aligned}$ | $\begin{aligned} & 220- \\ & 230 \end{aligned}$ | $\begin{aligned} & 230- \\ & 240 \end{aligned}$ | Mean Value |
|  | Percentage of Occurrence in Each Area |  |  |  |  |  |  |  |  |  |  |
| AVA |  |  |  | 0.1 | 0.7 | 6.2 | 32.7 | 59.7 | 0.6 | 0.0 | 209 |
| North-Asheville Basin |  |  |  |  |  | 0.1 | 13.5 | 82.8 | 3.6 | 0.0 | 213 |
| North-Highlands | 0.2 | 0.9 | 2.0 | 5.0 | 21.3 | 27.4 | 40.5 | 2.7 | 0.0 | 0.0 | 197 |
| East |  |  |  | 0.2 | 0.6 | 2.4 | 5.9 | 13.0 | 41.6 | 36.3 | 225 |
| South |  |  |  |  |  | 0.4 | 1.7 | 2.7 | 16.9 | 78.3 | 231 |
| West |  | 1.1 | 3.9 | 7.9 | 17.5 | 26.4 | 29.5 | 13.3 | 0.4 | 0.0 | 196 |

Table 8. Comparison of Length of growing season.

| Day Ranges | Elevation Ranges | AVA | North Asheville Basin | North Highlands | East | South | West |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Percentage of Occurrence in Each Area |  |  |  |  |  |
| $<160$ | $>5500^{\prime}$ |  |  | 1.1 |  |  | 1.1 |
| 160-170 | $\begin{aligned} & 4866^{\prime}- \\ & 5500^{\prime} \end{aligned}$ |  |  | 2.0 |  |  | 3.9 |
| 170-180 | $\begin{gathered} 4229^{\prime}- \\ 4866^{\prime} \end{gathered}$ |  |  | 5.0 | 0.2 |  | 7.9 |
| 180-190 | $\begin{gathered} 3592^{\prime} \\ 4229^{\prime} \end{gathered}$ | 0.6 |  | 21.3 | 0.6 |  | 17.5 |
| 190-200 | $\begin{gathered} 2955^{\prime}- \\ 3592^{\prime} \end{gathered}$ | 6.3 | 0.1 | 27.3 | 2.4 | 0.4 | 26.4 |
| 200+ | <2995' | 93.1 | 99.9 | 43.3 | 96.8 | 99.6 | 43.2 |

Table 9. Comparison of length of growing season by elevation zones.

## E) Growing Degree Days Analysis

Though the length of growing season reflects the number of frost-free days in an area, it is important to have sufficient warm temperatures during the frost-free period to properly ripen grapes. To integrate length of growing season with mean temperatures we have analyzed the study area using the concept of Growing Degree Days, also known as the Heat Summation method, popularized by Prof. A. J. Winkler ${ }^{24}$ in his well-known viticultural classification of California and subsequently applied worldwide by other workers. Winkler divided geographical areas into five categories (Table 10), called 'Winkler Regions' or 'Growing Degree Day Zones' based on the number of degrees that exceed $50^{\circ} \mathrm{F}$ in a month's mean temperature, that being the generally agreed temperature at which grapes begin to grow. ${ }^{25}$ Using the Prism Climate Group's 1981-2010 gridded temperature normals we have calculated Winkler Regions for 100-foot intervals for each of the study area terrains. The results of this analysis are summarized in Figure 17 and Table 11.

| Number of <br> Degree Days | Growing Degree <br> Day Zones | Climate <br> Conditions |
| :---: | :---: | :---: |
| 2500 or less | I (1) | Cooler |
| $2501-3000$ | II (2) |  |
| $3001-3500$ | III (3) |  |
| $3501-4000$ | IV (4) | Warmer |
| Greater than 4000 | V (5) |  |

Table 10. Growing degree day zone boundaries (after Amerine and Winkler, 1944).

| Comparison Areas | Growing Degree Day Zones |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 |  |
|  | Percentage of Occurrence in Areas |  |  |  |  |  |
| AVA | 1.3 | 18.1 | 77.5 | 3.1 |  |  |
| North-Asheville Basin |  | 6.6 | 89.7 | 3.7 |  |  |
| North-Highlands | 43.6 | 46.2 | 10.1 | 0.1 |  |  |
| East | 2.3 | 6.0 | 11.0 | 34.0 | 46.7 |  |
| South |  | 0.9 | 2.8 | 4.0 | 92.3 |  |
| West | 46.6 | 36.6 | 16.0 | 0.7 | 0.1 |  |

Table 11. Growing degree day zonation in the study area.

The majority of the AVA falls within Winkler zones II and III, while the major part of the Asheville Basin in the north comparison area is within zone III. Most of the terrain in the north-highlands and the

[^7]

Figure 17. Growing Degree Day zones.
west comparison area falls within Zones I and II, with small areas in Zone III. The east comparison area is mainly within Zones IV and $V$. The south area is almost exclusively within Zone V .

## F) Precipitation: Mean Annual, Growing Season and Winter

Water is the solvent that absorbs nutrients from the soil and delivers them through the roots into the vines, leaves and fruit. Water, therefore, in the form of rain, snow or from human irrigation is essential to growing wine grapes. Without sufficient water, vines may suffer heat and water stress and die. The mean annual precipitation in the study area ranges from a minimum of $36.4^{\prime \prime}$ in the Asheville Basin to a maximum of $93.5^{\prime \prime}$ in the west comparison area (Figure 18 and Table 12). Asheville Basin and the west comparison areas are the areas as well with the lowest and highest mean annual precipitation with $42.8^{\prime \prime}$ and $62.8^{\prime \prime}$, respectively. The proposed AVA has a mean value of $57.5^{\prime \prime}$. Interestingly the Asheville Basin has the lowest annual precipitation of any area of North Carolina, and the north-highlands area surrounding the Asheville Basin is a notable exception to the general rule that precipitation increases with increasing elevation. The precipitation profile in Figure 8 illustrates that the precipitation of the north-highlands is significantly lower than the lower-elevation AVA terrain. The relative dryness of the north comparison area is due to the rain shadow effect of the high mountains of the Blue Ridge escarpment and Blue Ridge crest/Eastern Continental Divide that are located east of the terrain. Moist winds from the Gulf of Mexico and the southeast Atlantic are cooled as they hit the precipice of the Blue Ridge escarpment and crest and drop their moisture along this front before sweeping further west into the Blue Ridge Plateau depleted of moisture.

| Comparison Areas | Mean Annual Precipitation in Inches |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Minimum | Maximum | Mean | Modal Range |
| Proposed AVA | 45.1 | 70.8 | 57.5 | $50-55$ |
| North-Asheville Basin | 36.4 | 50.5 | 42.6 | $35-40$ |
| North-Highlands | 37.9 | 72.3 | 50.7 | $45-50$ |
| East | 46.6 | 75.4 | 60.3 | $50-55$ |
| South | 45.9 | 82.4 | 60.2 | $45-50$ |
| West | 37.1 | 93.5 | 62.8 | $50-55$ |

Table 12. Comparison of mean annual precipitation.


Figure 18. Mean annual precipitation.

The recommended precipitation for mature grapevines during the seven-month growing season, from April 1 through October 31, is $24-30$ inches. ${ }^{26}$ Excessively high precipitation during the growing season can generate high humidity, a common condition in the southern Appalachians, which in turn promotes excess vigor, fungal diseases and attracts insects, all negative factors for sustainable viticulture. Insufficient water during the growing season leads to water stress in the vines, resulting in reduced photosynthesis and cell division, cell desiccation and potential death. Range of growing season precipitation for the study area is 21.5 to 51.02 inches, with the lowest mean values occurring in the north Asheville Basin and north-highlands areas, and the highest mean values in the west comparison area (Figure 19 and Table 13). The range between 24 and 30 inches covers $53 \%$ of the study area, and most of this area falls within the Asheville Basin and the north-highlands, and the lower elevations of the AVA, and of the east, south and west comparison areas. Mean growing season precipitation above 30 inches covers $47 \%$ of the entire study area and generally occurs at the higher elevations of the AVA and the surrounding comparison areas. The mean growing season precipitation of the proposed AVA is $33.17^{\prime \prime}$, a value that is lower than the west comparison area and higher than the north, east and south comparison areas.

| Comparison Areas | Mean Growing Season Precipitation in Inches |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Minimum | Maximum | Mean | Modal Range |
| Proposed AVA | 27.1 | 40.9 | 33.2 | $31-32$ |
| North-Asheville Basin | 21.5 | 31.2 | 24.5 | $22-23$ |
| North-Highlands | 22.2 | 42.3 | 28.7 | $26-27$ |
| East | 27.0 | 43.7 | 30.2 | $29-30$ |
| South | 25.0 | 47.1 | 29.7 | $28-29$ |
| West | 21.9 | 51.0 | 34.4 | $31-32$ |

Table 13. Comparison of mean growing season precipitation.

[^8]

Figure 19. Mean growing season precipitation.

Mean winter precipitation is another important metric for viticulture. Excessive precipitation during December, January and February can delay spring budbreak and pruning in vineyards, leading to late harvest and higher risk of early fall frost. The overall winter precipitation for the study area ranges from 8.4 to 24.5 inches. With a mean value of 15.96 inches the west comparison area is at the highest risk of excessive winter precipitation, and the north comparison area with 9.7 to 11.6 inches is at the lowest risk (Table 14 and Figure 20). The AVA has a mean value of 13.9 inches, which is an intermediate value between the lower values of the north, east and south comparison areas and the higher value of the west area.

| Comparison Areas | Mean Winter Precipitation in Inches |  |  |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Minimum | Maximum | Mean | Modal Range |
| Proposed AVA | 10.6 | 17.6 | 13.9 | $13-14$ |
| North-Asheville Basin | 8.4 | 12.0 | 9.7 | $9-10$ |
| North-Highlands | 8.9 | 18.6 | 11.7 | $10-11$ |
| East | 10.9 | 18.7 | 12.5 | $12-13$ |
| South | 12.0 | 20.9 | 13.4 | $12-13$ |
| West | 8.9 | 24.5 | 16.0 | $18-19$ |

Table 14. Comparison of mean winter precipitation.

## 



Figure 20. Mean winter precipitation.

## G) Viticultural Characteristics

Our analysis of environmental factors suggests that the AVA and comparison areas have somewhat different capacities for growing wine grapes. The environmental characteristics that are particularly relevant to determining the most appropriate grapes for these regions are average growing season temperature, growing degree days, length of growing season, elevation and precipitation.

The analysis of average growing season temperature demonstrates that all four of Prof. Gregory Jones's Climate/Maturity Groupings (Figure 12) are found in the study area (Figure 13 and Figure 14). Though the topography of the study area is complex with considerable variation in elevation, each comparison area tends to be dominated by one Climate/Maturity Grouping. The recommended V. vinifera varieties indicated by the average growing season temperature analysis are summarized in Figure 21.

The analysis of growing degree days shows as well that all five of the Winkler Regions, or Growing Degree Day Zones, are found in the study area, and also that the proposed AVA and each of the comparison areas is dominated by one or more of the zones. The recommended V. vinifera varieties based on this analysis are shown in Figure 22.

Length of growing season plays a major role on the varieties of grapes that can be grown in the study area. Mr. Robert Dobos (personal communication, November 6, 2016) of the National Soil Survey Center, an agency of the US Department of Agriculture, has kindly provided us with preliminary results of data on the grape varieties recommended for various growing season lengths. Dobos used this data in a computer application he developed for the US Department of Agriculture for determination of the best grape varieties in specific geographic areas, with length of growing season being a major criterion. Figure 23 summarizes the potential for V. vinifera in the study area, Figure 24 for FrenchAmerican hybrids, and Figure 25 for native American varieties.

From the five charts presented here and analysis discussed in the previous sections we can make the following generalizations about the wine grape potential of the study area:

- The AVA and all of the comparison areas have potential for cultivation of wine grapes, but in different capacities.
- The AVA falls mainly in the Warm Climate/Maturity Grouping, in Growing Degree Day zones II and III, and in the Medium Long to Long growing season category for Vitis vinifera; it falls in the Long season category for French-American hybrid grapes, and in the Very Long season category for native American varieties.
- The Asheville Basin of the north comparison area falls predominantly in the Warm Climate/Maturity Grouping, in Growing Degree Day zone III, and in the Medium Long to Long growing season category for Vitis vinifera; it is in the Long season category for French-American hybrids, and in the Very Long season category for native American varieties.

| Grape Varieties | Low Temp ${ }^{\circ} \mathrm{F}$ | High <br> Temp <br> ${ }^{\circ} \mathrm{F}$ | AVA | North -Ash. <br> Warm | North-highlands |  |  | East |  |  | South |  | West |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Warm |  | Warm | Inter | Cool | Inter | Warm | Hot | Warm | Hot | Warm | Inter | Cool |
| Müller-Thurgau | 55.58 | 59.09 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pinot Gris | 55.58 | 59.54 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Gewürztraminer | 55.58 | 60,17 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Riesling | 55.76 | 62.78 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pinot Noir | 57.20 | 61.16 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Chardonnay | 57.29 | 62.87 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sauvignon Blanc | 58.37 | 63.86 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sėmillon | 58.82 | 64.67 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cabernet Franc | 59.63 | 66.02 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tempranillo | 60.62 | 65.48 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Merlot | 60.80 | 65.84 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Syrah | 61.07 | 66.47 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Malbec | 61.25 | 66.11 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dolcetto | 61.52 | 65.39 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cabernet | 61.52 | 67.73 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Viognier | 61.88 | 65.84 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Grenache | 61.88 | 68.18 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sangiovese | 62.42 | 67.10 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Carignane | 62.87 | 68.36 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Zinfandel | 63.50 | 68.90 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Nebbiolo | 63.68 | 69.62 |  |  |  |  |  |  |  |  |  |  |  |  |  |

Figure 21. Recommended V. vinifera grape varieties based on Jones's Climate/Maturity Groupings determined by average growing season temperature. Dominant Grouping in each area shown in bold. Degrees Fahrenheit from Hannah et al, 2013, after Jones et al, 2005.

| Growing Degree Day Zones | Indicated Grape Varieties | AVA | North- <br> Ashe. <br> Basin | North-Highlands | East | South | West |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 (1) | Chardonnay |  |  |  |  |  |  |
|  | Pinot Noir |  |  |  |  |  |  |
|  | Riesling |  |  |  |  |  |  |
|  | Gewürztraminer |  |  |  |  |  |  |
| II (2) | Chardonnay |  |  |  |  |  |  |
|  | Pinot Noir |  |  |  |  |  |  |
|  | Riesling |  |  |  |  |  |  |
|  | Cabernet Sauvignon |  |  |  |  |  |  |
|  | Sauvignon Blanc |  |  |  |  |  |  |
|  | Cabernet Franc |  |  |  |  |  |  |
|  | Merlot |  |  |  |  |  |  |
| III (3) | Sauvignon Blanc |  |  |  |  |  |  |
|  | Sėmillon |  |  |  |  |  |  |
|  | Syrah |  |  |  |  |  |  |
|  | Zinfandel |  |  |  |  |  |  |
| IV (4) | Port |  |  |  |  |  |  |
|  | Barbera |  |  |  |  |  |  |
| V (5) | Muscat |  |  |  |  |  |  |
|  | Verdelho |  |  |  |  |  |  |

Figure 22. Recommended $V$. vinifera grape varieties for the study area based on Growing Degree Day zonation. Typical grape varieties from the Wikipedia article 'Winkler Scale,' accessible at https://en.wikipedia.org/wiki/Winkler scale.

| Growing <br> Season | Grape Varieties | AVA | NorthAshe. Basin | North-Highlands | East | South | West |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \text { Long } \\ \text { (>180 days) } \end{gathered}$ | Chambourcin |  |  |  |  |  |  |
|  | Vidal Blanc |  |  |  |  |  |  |
|  | Traminette |  |  |  |  |  |  |
|  | Norton |  |  |  |  |  |  |
| Medium <br> (170-180 <br> days) | Chancellor |  |  |  |  |  |  |
|  | Frontenac |  |  |  |  |  |  |
|  | LaCrosse |  |  |  |  |  |  |
|  | Seyval |  |  |  |  |  |  |
|  | Cayuga White |  |  |  |  |  |  |
|  | Vignoles |  |  |  |  |  |  |
| Short (160 days) | Leon Millot |  |  |  |  |  |  |
|  | Marechal Foch |  |  |  |  |  |  |
|  | Edelweiss |  |  |  |  |  |  |
|  | Aurore |  |  |  |  |  |  |

Figure 23. Recommended V.vinifers grape varieties for the study area based on length of growing season. After Robert Dobos, National Soil Survey Center, Lincoln, NB (personal communication, November 6, 2016).

| Growing Season <br> Long <br> (>180 days) | Grape Varieties | AVA | North- <br> Ashe. <br> Basin | North- <br> High- <br> lands | East | South |
| :--- | :--- | :---: | :--- | :--- | :--- | :--- | West

Figure 24. Recommended French-American hybrid grape varieties for the study area based on length of growing season. After Robert Dobos, National Soil Survey Center, Lincoln, NB (personal communication, Novmber 6, 2016.

| Growing Season | Grape Varieties | AVA | North- <br> Ashe. <br> Basin | North-Highlands | East | South | West |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { Very long (>180 } \\ & \text { days) } \end{aligned}$ | Norton (Cynthiana) |  |  |  |  |  |  |
| $\begin{gathered} \text { Long } \\ \text { (170-180 days) } \end{gathered}$ | Concord |  |  |  |  |  |  |
|  | Niagara |  |  |  |  |  |  |
|  | Catawba |  |  |  |  |  |  |
| $\begin{gathered} \text { Medium } \\ \text { (150-170 days) } \end{gathered}$ | Buffalo |  |  |  |  |  |  |
|  | Fredonia |  |  |  |  |  |  |
|  | Alden |  |  |  |  |  |  |
|  | Delaware |  |  |  |  |  |  |
|  | Steuben |  |  |  |  |  |  |
| $\begin{gathered} \text { Short } \\ \text { (130-150 days) } \end{gathered}$ | Van Buren |  |  |  |  |  |  |

Figure 25. Recommended native American grape varieties for the study area based on length of growing season. After Robert Dobos, National Soil Survey Center, Lincoln, NB (personal communication, November 6, 2016).

- The east comparison area is predominantly in the Hot Climate/Maturity Grouping, Growing Degree Day zones IV and V, and the Medium to Long season category for Vitis vinifera; it is in the Short to Long season category for French-American hybrids, and in the Medium to Very Long season category for native American varieties.
- The south comparison area is predominantly in the Hot Climate/Maturity Grouping, Growing Degree Day zone V, and the Medium Long to Long season category for Vitis vinifera; in the Long season category for French-American hybrids, and in the Very Long season category for native American varieties.
- The west comparison area is mainly in the Intermediate Climate/Maturity Grouping, Growing Degree Day zones I and II, and Short to Long season categories for Vitis vinifera; Short to Long season categories for French-American hybrids, and Medium to Very Long season categories for native American grapes.
- Higher elevation areas (above 4866' for sure and most likely even lower elevations) that occur in the north-highlands and west comparison area have a growing season that may be too short or marginal for fully ripening wine grapes. In addition these areas are at high risk for severe winter conditions that can cause damage to and kill grape vines. These areas are most likely are not viable for sustained viticulture.
- The west comparison area is the area most at risk for excessive growing season precipitation and thus at higher risk for high humidity, excess vigor, fungal diseases, and harmful insects.
- The north comparison area (Asheville Basin and the north-highlands) is the most susceptible terrain to drought and insufficient precipitation during the growing season.


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    ${ }^{3}$ In 1933 the New Deal's Public Works Administration approved funding for a scenic route to extend Virginia's Skyline Drive south to connect the Shenandoah National Park with the developing Great Smoky Mountains park, resulting in the present day Blue Ridge Parkway, which follows or parallels the crest of the Blue Ridge from southern Virginia to a point north of Asheville, NC.
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    ${ }^{6}$ The maps are Fruitland, NC, Bat Cave, NC, Cliffield Mountain, NC, Hendersonville, NC, Horse Shoe, NC, Standingstone Mountains, SC-NC, Zirconia, NC, and Saluda, NC.

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    ${ }^{22}$ The calculation was done using the Prism Climate Group's 1980-2010 monthly climate normal rasters for the period of April 1 through October 31. These seven rasters were added together using the ESRI Spatial Analyst Math Calculator and divided by seven (7) to produce the final mean growing season temperature raster for the AVA and comparison areas.

[^6]:    ${ }^{23}$ Vineyards Site Evaluation. College of Agriculture and Life Sciences at Cornell University and the Institute for the Application of Geospatial Technologies, n. d., Web. 16 Nov. 2014. http://arcserver2.iagt.org/vil//

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