American Viticultural Area Petition
for
EASTERN CONNECTICUT HIGHLANDS

Pursuant to the provisions of 27 CFR Section 93 and Section 4.25a (e)(2) we respectfully petition the Alcohol and Tobacco Tax and Trade Bureau to establish a new American Viticultural Area (AVA) in Connecticut called Eastern Connecticut Highlands.

Proposal for establishment of a new AVA in Eastern Connecticut

Because the underlying rocks are the foundation upon which all ecology rests, we propose the designation of an American Viticultural Area (AVA) based on geologic boundaries. In Connecticut in particular, it is the underlying geology that exerts major controls on the physical parameters of the area. Soil type in most areas is controlled by the underlying parent material, even in a glaciated area such as Connecticut. The underlying rocks and their erodibility, particularly in Connecticut, exerts a first order control of the topography and elevation and the topography, especially elevation strongly influences microclimates in the state. These factors are important in establishing regionality of agriculture, especially viticulture. Hence, it makes ultimate sense to us to establish a viticultural area based on geologic factors, as will be discussed below. We do recognize however, that the quality of wine produced in a region, perhaps the region's *terrior*, also has to do with the wine-makers and local wine-making traditions, which of course have nothing to do with geology (Stone and Thomas, 2014).

Figure 1. *The valley in front of the skyline is a geologic terrane boundary and the eastern border of the proposed Eastern Connecticut Highlands AVA. (Pictures taken at Sharpe Hill Vineyard.)*

NAME EVIDENCE

The suggested name is ***Eastern Connecticut Highlands***, a geographical term that has been in use for over a hundred years (Davis, 1898; Burr, 1904). Highlands, referred to in some of the older literature and usage as uplands, flank a central lowland area in both Connecticut and Massachusetts. The lowland is underlain by relatively young easily eroded sedimentary and igneous rocks. The Connecticut River flows through the lowland area. The highlands, on the other hand, are underlain by older rocks that are more difficult to erode and hence they stand with higher relief. The highlands are referred to as the western highlands and the eastern highlands. It is this geographic term, western highlands, that the petitioner for the Western Connecticut Highlands AVA used for their name evidence; they added Connecticut, as we also propose, to distinguish the highlands of Connecticut from the highlands of Massachusetts.

The term *eastern highlands* (western highlands as well) has been used in the geographic, geologic and climatologic literature for many years to describe the highland/upland areas to the east and west of the Central Valley of Connecticut (in addition to those references illustrated in Appendix 3, see Davis, 1898, Burr, 1904, Krynine, 1939 and 1950, Bixby, 1974, Bell, 1985, Lewis and Harmon, 1986). On the internet Eastern Highlands is referred to by geologists, mineral collectors and other outdoor enthusiasts. Recently, a newly created regional health district adopted the name Eastern Highlands. (See internet search results in Appendix 3.) The general public, however, does not commonly refer to the "Eastern Highlands....or the "Western Highlands", for that matter. Were it not for the recognition gained solely by naming the AVA Western Connecticut Highlands, the Eastern Highlands, because of the Health District, would have greater name recognition.

The highlands continue northward into Massachusetts and New Hampshire and include parts of northeastern Rhode Island as well. Restricting the proposed AVA area to the highlands in Connecticut is done because at this time there is less viticulture in the highlands of eastern Massachusetts and New Hampshire. Also, Massachusetts and New Hampshire are slightly higher in elevation and of course farther north, both of which result in slightly colder climate. The higher elevations of Rhode Island diminish gradually eastward and gradually become increasingly impacted by the coastal regime that defines the Southeastern New England AVA (indeed the northeastern boundary of the Southeastern New England AVA is located only a few tens of miles east of the CT-RI border). Last but not least, it would be somewhat awkward to have the Eastern *Connecticut* Highlands include Rhode Island, Massachusetts or New Hampshire.

In summary, we contend that there is more name evidence for the Eastern Connecticut Highlands at this time than there was for the Western Connecticut Highlands at the time of its AVA petition (See Appendix 3).

BOUNDARY EVIDENCE

The boundary of the proposed Eastern Connecticut Highlands follows geologic boundaries, specifically some of the geologic terrane boundaries. A geologic terrane is a contiguous group of rocks that has a shared geologic history distinct from abutting terranes. (Figure 2). Rocks in the geologic terranes of both Connecticut highlands (eastern and western) are more resistant to erosion and because of that they stand with greater relief and elevation, creating natural physiographic provinces. Thus, it is the geology that influences topography (elevation), elevation influences climate; geology and climate influence soils and geology and soils influences groundwater chemistry[1].

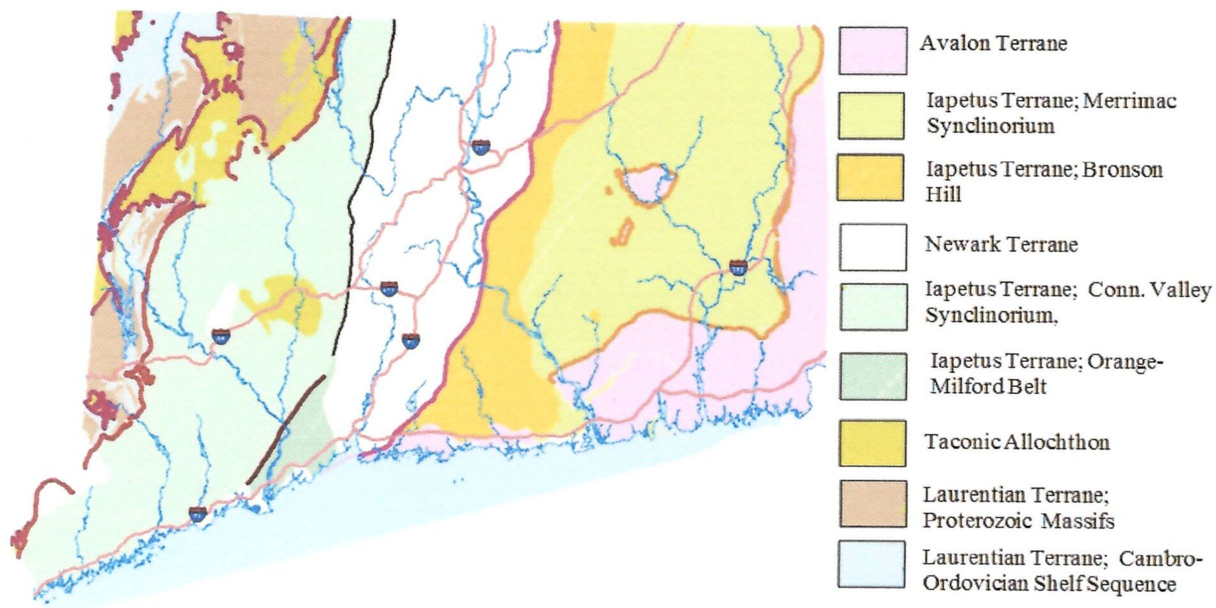

Figure 2. *Geologic terranes of Connecticut (after Rodgers, 1985). Heavy lines at terrane boundaries (not to be confused with the interstate highways) are major faults.*

Boundary for the proposed Eastern Connecticut Highlands AVA. The boundaries of this proposed AVA closely follow geologic terrane boundaries in Eastern Connecticut: to wit, the Lake Char Fault on the east, the Honey Hill Fault on the south and the Eastern Border Fault of the Mesozoic Hartford Basin on the west (Figure 2). To some extent these geologic features have influenced topographic development of the region and roadways that follow the topography mimic the geologic boundaries; in those cases we have proposed the roadways for the AVA boundary. For ease in delineating on a map showing largely cadastral features, and to avoid overlap with the neighboring Southeastern New England AVA, the proposed AVA boundary in places is more than a mile from the terrane boundary.

1. "The configuration and elevation of the Earth's surface, the plants that are distributed on this topography, and indeed, the nature of human habitation are controlled by the underlying geology (Hine, 2013). To put it more succinctly, no geology, no ecology (Shinn, 2013).

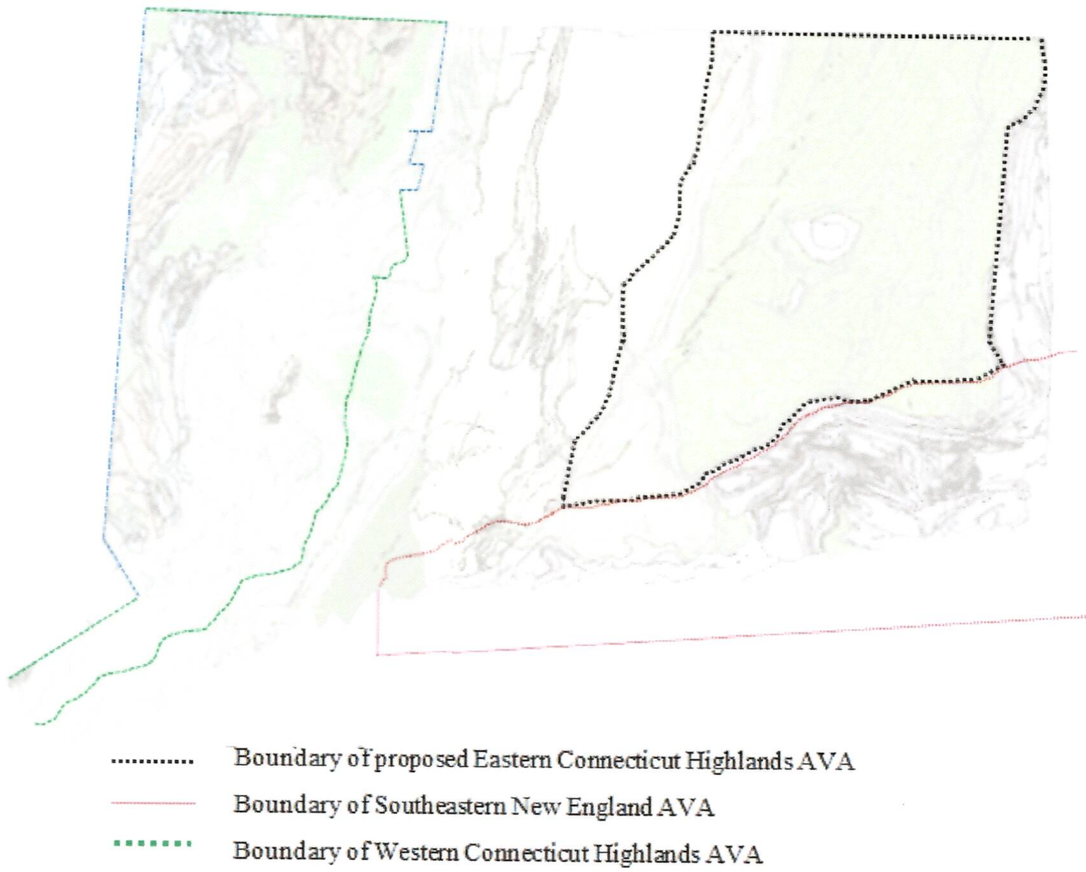

Figure 3. Boundary of proposed Eastern Connecticut AVA, the boundary of the Western Connecticut Highlands, and part of the boundary of Southeastern New England AVA superposed on geologic terrane map of Connecticut.

Approved Map (with outline of proposed AVA).

State Map of Connecticut, U.S. Geol. Survey, 1:125,000, 1965.

Boundary description.

1. Beginning at a point in Somers where State Hwy. 83 intersects the Massachusetts/ Connecticut state line (which is about a mile west of the terrane bounded by the Eastern Border Fault), the proposed AVA boundary heads east along the state line approximately 33 miles to a point in Thompson where the state line intersects an unnamed road, locally known as Bonnette Ave
2. There the boundary turns southeast to follow Bonnette Ave. approximately three eighths of a mile and continues southeasterly following another unnamed road, locally known as Sand Dam Road, for about a mile and a half to the intersection of Sand Dam Road with Thompson Road, also unnamed on the map.

3. The proposed boundary then jogs south for about 1000 feet along Thompson Road and then heads southeasterly on another unnamed road locally known as Quaddick Town Farm Road, and follows that road easterly and southerly approximately 5.5 miles where it crosses into the town of Putnam and is locally known as East Putnam Road. East Putnam Road intersects US Rte. 44 in about mile.
4. The boundary then heads west on US Rte. 44 for about one mile where it intersects an unnamed road, locally known as Tucker Hill Road.
5. The proposed boundary goes south on Tucker Hill Road approximately three eighths of a mile to its intersection with an unnamed road locally known as Five Mile River Road where it heads southwest and west one and three-quarter miles to State Hwy. 21.
6. The proposed boundary follows State Hwy. 20 south about 2 miles where it intersects State Hwy. 12 and follows State Hwy. 12 another mile south to the Five Mile River.
7. The proposed boundary then follows the Five Mile River west about one eighth of a mile where it goes under State Hwy. 52, now known as Interstate 395.
8. Because State Hwy. 52, now known as I-395, roughly follows the trace of the Lake Char Fault the proposed boundary then follows I-395 approximately 14.5 miles southward to its intersection with State Hwy. 201.
9. The proposed boundary thence follows State Hwy. 201 approximately 5.25 miles to its intersection with State Hwy. 165.
10. At this point the proposed boundary will follow the northern boundary of the Southeastern New England AVA (despite it being more than a mile, in places, either north or south of the geologic terrane boundary in places) in a general southwesterly and westerly direction for approximately 56 miles along State Hwys. 165, 2, 82, 9 and 80 to the intersection of State Hwy. 80 with State Hwy. 77 in the town of Guilford.
11. Thence the proposed AVA boundary heads generally north along State Hwy. 77, which closely follows the fault-controlled topography (Eastern Border Fault), for approximately16 miles to Middletown, where State Hwy. 17 joins State Hwy. 9.
12. State Hwy. 17 follows State Hwy. 9 approximately three-quarters of a mile and then crosses the Connecticut River on the Arragoni Bridge and proceeds another quarter mile where the proposed boundary heads north following State Hwy. 17A for three miles where it rejoins State Hwy. 17.
13. From that point the proposed boundary follows State Hwy. 17 northward along the fault line escarpment of the Eastern Border Fault, approximately 8 miles, to the intersection of State Hwy. 17 with State Hwy. 94.
14. Thence the proposed boundary follows State Hwy. 94 about 4 miles eastward to its intersection with State Hwy. 83.

15. From that point the proposed boundary roughly follows the Boarder Fault northward along State Hwy. 83 for about 25 miles to the starting point in Somers at the Connecticut/Massachusetts state line.

GEOLOGICAL EVIDENCE.

Geology is the underpinning of all the physical and biological parameters that comprise ecology. The rocks are the foundation on which everything else rests. The physical make-up of the rocks exerts a first order control on the physiography of the land…the lay of the land if you wish. The varying resistance to erosion of the rocks of Connecticut determines the topography of the state and defines the physiographic provinces. The composition of the underlying rocks determines many parameters of the soil that rests upon the rocks as well as the chemical characteristics of both groundwater and surface water that comes in contact with those rocks. Thus it is our contention that AVA boundaries should strongly consider the nature of the rocks in the area.

The rocks of Connecticut can be divided into four generalized terranes (Bell, 1985, Rodgers, 1985 Skehan, 2008). The northwestern part of the state is underlain by the eastern margin of the ancestral North American continent. Geologists refer to the continent as it existed then (~600 m.y.a.) as Laurentia. To the east of Laurentia was an ancient ocean, called Iapetus, that lapped up onto the Laurentian continental shelf and slope.

The Eastern Connecticut Highlands are underlain by Paleozoic rocks generally regarded by geologists (Coleman, 2005) as Iapetus Terrane (Fig. 2, Table 1) although it turns out that they formed as microcontinents on the eastern side of the Iapetus Ocean close to the present day

Table 1. Bedrock characteristics.

	Eastern Connecticut Highlands (proposed AVA)	Central Lowlands (west of proposed AVA)	Avalon Terrane (south and east of proposed AVA)
Terrane	"Iapetus"; Putnam-Nashoba, Central Maine, Merrimac, Bronson Hill	Mesozoic Basin	Avalon , Gander
Ages of rocks	270 - 500 m.y.	~200 m.y.	900 - 1100 m.y; 610 - 650 m.y
Lithologies	Metasedimentary and metaigneous (including metavolcanic) rocks; granite gneiss of various compositions, schist and sulfidic schist, granofels and calc-silicate gneiss, gabbro.	Sedimenatary sandstone, conglomerate, shale, siltstone, minor limestone. Igneous rocks: basalt and diabase	Metaigneous and metasedimentary rocks. Mostly granitic gneiss with quartzite to east of proposed AVA and granitic gneiss, schist and quartzite with intrusive granite south of proposed AVA.
Typical formations	Canterebury Gneiss, Brimfield Schist, Hebron Gneiss, Scotland Schist, Littleton Schist, Clough Quartzite, Glastonbury Gneiss, Middletown Gneiss, Monson Gneiss, Tatnic Hill Formation, Quinnebaug Formation, Lebanon Gabbro, Preston Gabbro	Portland Formation, Hampton Basalt, East Berlin Formation, Holyoke Basalt, Shuttle Meadow Formation, Talcott Basalt, New Haven Formation	Hope Valley Gneiss, Sterling plutonic suite, Plainfield Formation, Waterford Group,

1. Data from Rodgers, 1985.

Baltic states (Wintsch et al., 2012 and ref. therein). They are the metamorphic equivalents of sedimentary and volcanic rocks that initially were deposited along an ancient continental slope and border land well to the east of the Laurentian continent on the eastern side of the Iapetus Ocean. The sedimentary and volcanic rocks accreted onto the North American continent over a span of millions of years, ending about 275 million years ago (Wintsch and others, 2012). Today these rocks comprise the Canterbury, Glastonbury, Monson, Middletown, and Eastford Gneisses, the Scotland, Littleton, and Brimfield Schists, the Hebron, Tactnic Hill, and Quinnebaug Formations, the Preston and Lebanon Gabbros and the Clough Quartzite. Prior to being metamorphosed they were sandstone, shale, some calcareous shale, silicic and intermediate volcanic rocks, some sulfidic volcanics, and shallow intrusive rocks. It is interesting to note, as an aside, that similar non-metamorphosed younger rocks of comparable chemical and mineralogical composition underlie much of California's wine regions!

Rocks to the east and south of the proposed AVA are part of a different geologic terrane, Avalonia. They are older, Pre-Cambrian in age, and have a slightly different chemical composition (Robinson and Kupo, 2003). Rocks to the west are younger (Mesozoic) stratified rocks, sandstone, and shale with three interbedded basalt lava flows. The Mesozoic rocks have a different chemical composition and lead to vastly different soils (see following section). Rocks of the Western Highlands consist the ancient (pre-Cambrian) proto-North American continent and rocks deposited during the Paleozoic along the proto-North American continental shelf.

Surficial materials are related to their proximal bedrock source and variations in bedrock geology closely correlate to variations in the properties and chemistry of surficial materials (see soils section of this proposal) and chemistry of surficial and near surface groundwaters (Table 2.; see Robinson and Kapo, 2003, and references therein)

Table 2. Chemical characteristics of near surface waters[1].

Eastern Connecticut Highlands (proposed AVA)	Central Lowlands (west of proposed AVA)	Avalon Terrane (south and east of proposed AVA)
Most metamorphic rocks: Generally low solute concentrations, low pH and high K:Al ratios; pelitic rocks have low to moderate solute concentrations with generally low Ca:Na and variable K:Na.	Sedimentary rocks: Generally high [Na] and sometimes high [Ca] and [SO_4]. Groundwater may have high solute concentrations where acidic or high [SO_4] exist, high [Fe] where Eh and pH are low.	Metamorphic rocks: Generally low solute concentrations, low pH and high K:Al ratios. Granite: low solute concentrations with relatively high [HCO3] and [Si]; generally low [Ca] and [Mg]; acidic pH
Some schist is sulfidic and have moderate sollute concentrations with high [Fe] where Eh and pH are low	Basalt (traprock): High (Ca, Mg):Na ratio, variable [Si] and high [Fe] and [Mn] where Eh and pH are low.	
Granite: low solute concentrations with relatively high [HCO_3] and [Si]; generally low [Ca] and [Mg]; acidic pH		
Mafic r ocks: High [Ca], [Mg], and [Na], variable [Si] and high [Fe] and [Mn] where Eh and pH are low.		

1. Data from Robinson and Kapo, 2003.

Glacial geology. Several times during the past million years (the Pleistocene Epoch) great ice sheets have covered parts or all of New England. The latest episode of cold climate began moderating approximately 20,000 years ago (see Figure 4; Stone and others, 2005). The last great glacial ice sheet extended south as far as Long Island-Block Island-Cape Cod and was a mile or more thick in Connecticut.

Glaciers are defined as ice of sufficient thickness that it flows, being driven by differences in weight which is a direct function of thickness. Because it is colder to the north, snow and ice accumulated to greater thicknesses there and hence the large ice sheets flowed generally from north to south, or some variation thereof. In Connecticut, ice flowed in a south-southeasterly direction during the last glacial episode. Ice a mile thick moving over the land easily is able to remove most soil and erode the underlying bedrock. Glacial activity is a powerful sculptural agent on the land and produce spectacular landscape. Also, as a result of this erosional activity, much soil and rock debris gets frozen into the base of the glacier and some may be deposited beneath the glacier, referred to as lodgement or basal till, especially near the end of an ice age when melting begins. Material deposited beneath the glacier is referred to by the term till. Till is freshly-ground rock and hence contains a wealth of mineral nutrients. Soils formed on till are generally agriculturally productive. Ablation or meltout till is the debris that is left where the ice melted. Ablation till tends to contain less muddy materials and to be less compact than lodgement till. Lodgement till tends to be less permeable than ablation till and in many places is referred to as hardpan.

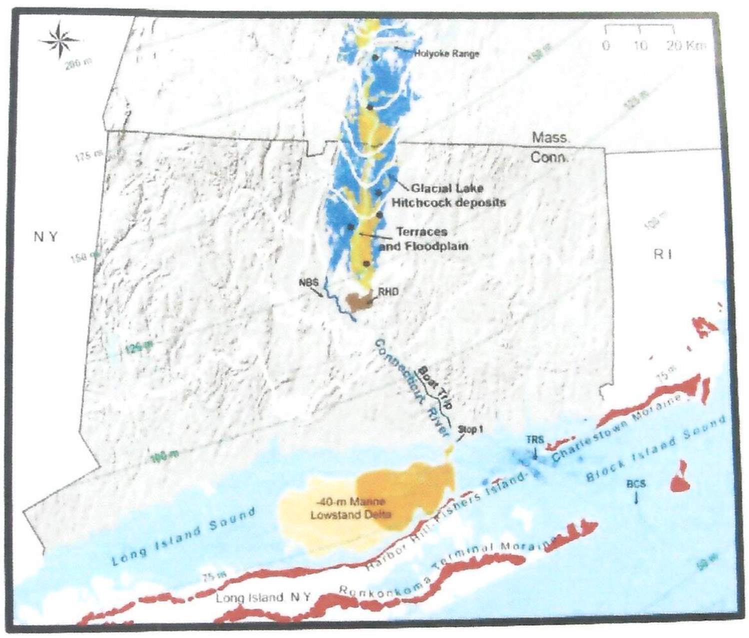

Figure 4. Retreating (melting) ice margin locations (white lines) at end of last Ice Age. Dates in thousands of calendar years. Red lines are terminal morains formed during maximum advance of the glaciers. Blue area shows extent of glacial meltwater lakes. Picture is cover of Stone and others, 2015.

Melting glaciers at the end of the Ice Age produced torrents of meltwater that coursed down the major valleys transporting tons of debris formerly frozen into the glacial ice. The meltwater transported deposited mud in local lakes or washed it into the sea, the ultimate destination of all the melted ice. The same streams deposited layers of sand and gravel on their river-beds and along their banks forming the raw material for the numerous gravel pits in the region. The stratified sand and gravel deposits also form productive local aquifers.

Geological effects on viticulture. The known influence of bedrock geology on viticulture in Connecticut is more indirect than direct. The rocks have a strong influence on topography (discussed in the next section) which affects microclimates which affect viticulture (discussed in a coming section). The bedrock geology strongly influences the soils and soil chemistry, which is being found in other areas to have an important influence on wine quality (this also will be discussed in a coming section). Generally the chemistry of rocks in the Eastern Highlands is remarkably similar to chemistry of rocks in several of the California wine producing areas (Carmel, Monterey, Napa-Sonoma, Paso Robles, Santa Barbara, Temecula, and others) and indeed the rocks in the Eastern Highlands are older metamorphosed varieties of the rocks that underlie much of the California wine areas.

TOPOGRAPHIC EVIDENCE

Connecticut is characterized by hilly highlands (also referred to as uplands) bisected by a low lying, north-south oriented central valley, all fringed by a coastal slope. The Eastern Highlands (Figure 5) is east of the Central Valley and occupies about 40% of the state. Elevations range from about 200 feet in valley floors to just more than 1000' in the highest elevations in the north.

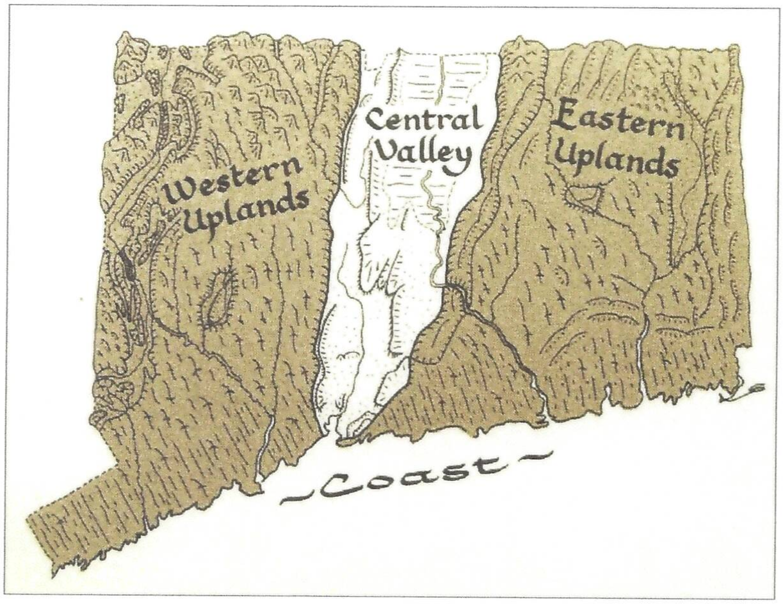

Figure 5. Sketch map showing the physiographic provinces of the state of Connecticut. Bell is one of the few modern authors who refers to the highland areas as "uplands". Although he does not outline the Coastal Slope in this map, a separate pattern on the map clearly shows it. (From Bell, 1985, p.10)

The western border of the highlands is a major, inactive, geological fault. Along this great fracture in the upper part of Earth's crust, rocks on the west were dropped downward and rocks on the east were raised. Offset totaled about 5 miles and resulted in easily erodable sedimentary rocks to the west being juxtaposed against more difficult to erode metamorphic rocks to the east. The fault is the eastern bound of a geologic province referred to as the Hartford Basin and is called the Eastern Border Fault (Rodgers, 1985). It can be traced south-southwestward through Connecticut from Ellington to Manchester to East Haven.

The Eastern Highlands are subdivided into several regions on the basis of topography and geology (Figure 6). Running parallel to the Eastern Border fault is an almost continuous ridge, referred to as the Bolton Range (Bell, p.44), of erosionally resistant metamorphic rocks. It stretches from Stafford, through Bolton Notch and southward to Killingworth. Curiously, I-84 runs through one of the breaks on the ridge and the Connecticut River through another. Along the Rhode Island border and swinging westward parallel to the coast as far as Lyme, is another range of ridgy terrain Bell refers to as the Mohegan Range (a name that has not caught-on). The western border of the Mohegan Range is the Quinnebaug River Valley which flows parallel to the trace of the Lake Char Fault (Rodgers, 1985). Where the Range swings around to the west the northern border is formed by the Honey Hill Fault (a continuation of the Lake Char Fault that was named separately before it was realized they were tha same feature). More resistant metamorphic rocks and granite are found on the east and south side of the faults.

For the remaining central part of the Eastern Uplands, Bell coined the name *Windham Hills* (a reasonable name that is infrequently used).

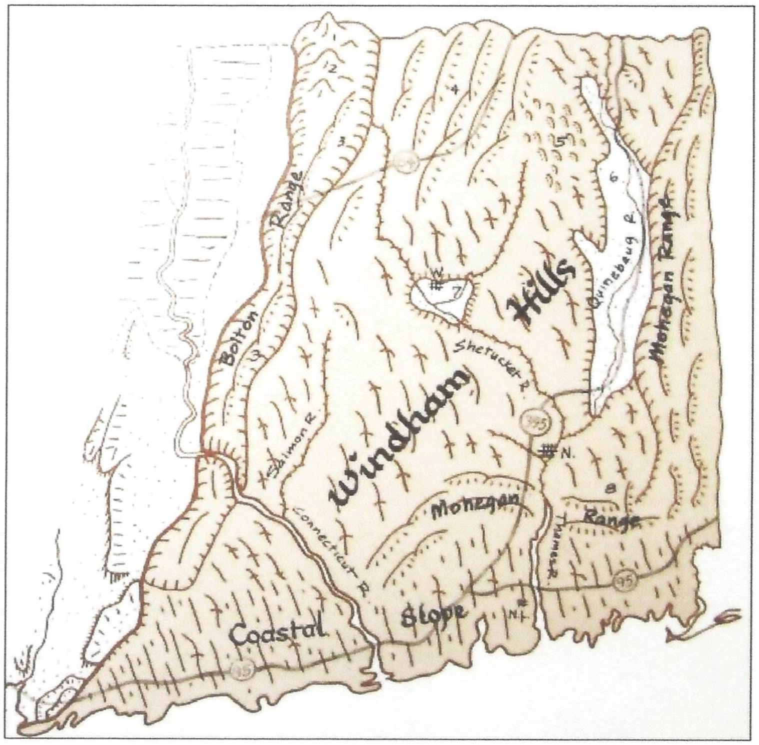

Figure 6. *Details of the Eastern Highlands, showing the Bolton and Mohegan ranges. These ranges are roughly parallel to the geologic terrane boundaries and thus roughly outline the boundaries of the proposed AVA. The Coastal Slope is designated on this map. From Bell, 1985, p.45.*

The Windham Hills are “a herd of hills, closely crammed together, almost nudging each other for more space” (Bell, p.42). When seen from a good vantage point (and Sharpe Hill, Figure 1, is one such point) the hill and ridge tops have rather concordant elevations; that is adjacent hill tops have about the same elevation as their neighbors have. Hill top elevations are higher to the north and lower to the south and one can imagine, as did Bell, of placing a gigantic sheet of plywood on top of the hills. The plywood would form plane sloping gently southward at about 10-20’/mile.

The land of the Windham Hills is gentler and more rounded than the ridgy ranges to the east and west. Smooth, streamlined bedrock hills and in some places, drumlins, appear like so many sheep hunkered down close together to survive the elements. It is a leisurely landscape of lush forests and pastoral scenery that was sculpted during the last Ice Age when a mile thick ice-sheet scraped southward shaping the hills of the region. Furthermore, the soils developed on glacial till (debris left when the ice melted) and in many places are thick and in most places are agriculturally productive. Like most Connecticut soils, however, they tend to be rocky. But, of course, the by-product of farming on rocky soils in New England is the region’s revered stone fences and walls (Thorson, 2002).

The Coastal Slope (shown on Figure 5 by a pattern change along the coastal area and by designation on Figure 6), lying south of the eastern and western highlands, includes areas significantly affected by maritime climate. It extends about 10 +/- miles inland. The elevations range from sea level to 300-400’ inland. Hill top elevations generally decrease systematically from north to south with a slope of 30-40’/mile. The shoreline consists of rocky prominences separated by coves and tidal lands that may extend several miles inland. There are numerous small bedrock islands and a scattering of small islands formed by recessional moraines.

The Central Valley is a north-south physiographic region lying to the west of the Eastern Highlands (see Figure 5). It is a broad flat valley developed on relatively weak stratified rocks of Mesozoic age (~200 million years ago). The rocks consist of sandstone and shale and more resistant lava flows of basalt, known as traprock, exposed as high ridges that bisect the valley. The valley floor ranges in elevation from sea level in the south to 150-250' in the north. The Connecticut River has an elevation of about 50' at the Massachusetts border. The traprock ridges range from 500-1020' elevation. The sandstone and shale are generally reddish brown in color and most of the soils in the valley are also.

The major importance of topography to viticulture lies in the climatic modification caused by elevation and relief. The higher elevations in the Eastern Highlands cause a generally colder climate and that affects the varieties of grapes that can be successfully grown in any given area (see *Climate Evidence* in next section).

CLIMATE EVIDENCE.

The prevalent atmospheric flow is toward the east at the latitude of Connecticut. As such the dominant systems that most affect the state are continental polar air masses associated with high pressure over Canada and tropical maritime air masses associated with high pressure in the region of Bermuda. Only rarely is the state affected by maritime polar air when "back-door" cold fronts move across the region. The interaction and conflict between the two major systems create most of the changing weather pattern and storms that the state experiences.

Both systems stay active throughout the year at this latitude and result in precipitation that is fairly evenly distributed through the seasons: although there may be dry or wet periods, there is no "dry season", or no "wet-season". Winter precipitation is brought by coastal cyclones that may produce rain or snow during "nor'easters" that typically form over the mid-Atlantic seaboard and track northeastward along the coast. Summer precipitation is brought by cold frontal passage and the resulting storms created by convection and warm air advection at the leading edge of the cold air. Precipitation is usually in the form of rain (sleet/or snow in early spring) during the passage of squalls and thunderstorms.

This being said, within the state of Connecticut spacial differences are created by elevation and closeness to Long Island Sound. The waters of Long Island Sound are slow to absorb heat in the spring but likewise are slow in giving up their heat during the fall and winter. As a result, the temperature maximum of sound waters occurs in late summer/early autumn and in similar manner the coldest water temperatures occur in late winter. Any time the wind blows over Long Island Sound waters the air temperature is altered by the water temperature. When maritime air moves inland it moderates the air temperature inland. Because of this sound waters have a profound effect on temperatures of the coastal region: in the winter south and southeasterly flow associated with approaching cyclones moderates the cold and in the summer sea breezes caused by warm air convection inland cools coastal regions and often regions some distance inland.

A second factor that causes differences in temperature is the land elevation. The physics of air is such that the pressure, temperature, and volume of air are interrelated. Increasing elevation encounters lower air pressure and lower air pressure results air expansion which decreases the temperature. This is the venturi effect and is the basis for creating cold air in freezers, refrigerators and air conditioning units. As you increase in elevation the temperature normally decreases at a rate of 4-7°F/1000 ft (this is referred to as the adiabatic lapse rate). Mountain top daytime maximum temperatures are almost always colder than valley bottoms temperatures (temporary nocturnal inversions commonly occur in many valleys because cold air is more dense that warm air and it may sink to the valley bottom during calm night-time conditions). Areas of higher elevation are normally cooler than lower elevations.

A combination of these two effects create different climatic regions of Connecticut (see Table 3 and Appendix Table 1): *Highland* regions in the eastern and western parts of the state, a *Central Lowland* and a *Coastal Plain.* The *Central Lowland* climatic region includes the Connecticut River Valley north of Middletown and merges with the coastal plain south of Middletown. It is clearly shown separating the *Eastern Highland* climatic region and *Western Highlands* region on a map that shows average annual temperature (Figure 7). The *Eastern Highlands* lie east of the Central Lowland and north of the Coastal Plain. The Eastern Highlands climatic region is roughly coincident with the AVA proposed herein. The *Western Highlands* lies west of the Central Lowlands and north of the Coastal Plain. The *Coastal Plain* climatic region is a narrow coastal belt about 10 miles wide that runs along the entire south coast. It is most clearly

TABLE 3. Climate summaries								
A. 1996-2015 Climate Summary (1)								
		Average T°F	Growing Degree days (heat summation).	Coldest Temp. recorded for period	Ave. Date latest frost, Spring	Ave. date first frost, Fall	Date Ave. Temp. greater than 32°F	Date Ave. Temp. less than 32°F
Eastern Highlands	Windham Airport	50.1	2780	-13°F	May 3	October 15		
Central Valley	Windsor Locks	51.3	3036	-11°F	April 23	October 15		
	Hartford	52.2	3185	-4°F	April 12	October 23		
Coastal Slope	Groton	51.5	2709	-5°F	April 18	Octover 26		
	New Haven	52.5	3057	-2°F	April 9	November 1		
B. 1981-2010 Climate Summary (2)								
Eastern Highlands	Coventry	47.2					na	na
	Hampton	48.1					April 8	November 9
	Mansfield Hollow	48.3					April 9	October 30
	Staffordville	47.6					April 11	November 5
	Storrs	49					March 30	November 24
	West Thompson	47.8					April 11	November 1
	Windham Airport	49.5					April 4	November 13
Central Valley								
	Hamden	51.3					na	na
	Hartford	51.2					March 22	November 24
	Meridan	50.4					March 31	November 14
	Middletown	51.7					March 27	November 28
	Mount Carmel	51.5					March 29	November 25
	Windsor Locks	50.6					March 29	November 20
Coastal Slope								
	East Haven	52.1					na	na
	Groton/New London	50.4					March 27	November 29
	New Haven	52.2					March 20	December 4
	Norwich	50.6					March 31	November 17

1. Data compiled from https://www.wunderground.com/history/airport/
2. Data compiled from http://www.usclimatedata.com/climate/connecticut/united-states/3176 and http://www.canr.uconn.edu/nrme/cscc/ClimateData.php

delimited by maps that show isochrons of the average last spring frost and the average first fall frost (Figure 8). Note also that these maps also delineate the lowland and highland regions.

Note that the data sets summarized in Table 3 are from slightly different time-spans and show the effect of global warming has on climate averages. Data from these sets have been superposed purposely in data from 1931-1961 shown on Figures 6 and 7 to illustrate that phenomena. Average temperatures have increased about three degrees and the growing season (difference between last spring frost and first fall frost) has lengthened be 15-20 days. The greatest increase has occurred in the last 20 years as can be seen by comparing the average temperature shown in Table 3B with that of Table 3A which uses more recent data.

Also shown in Table 3A are growing degree days (heat summation of Winkler) and lowest temperatures recorded during the more recent time period. Growing degree data are shown in Table 3A using only data from the past twenty years. These data show the central

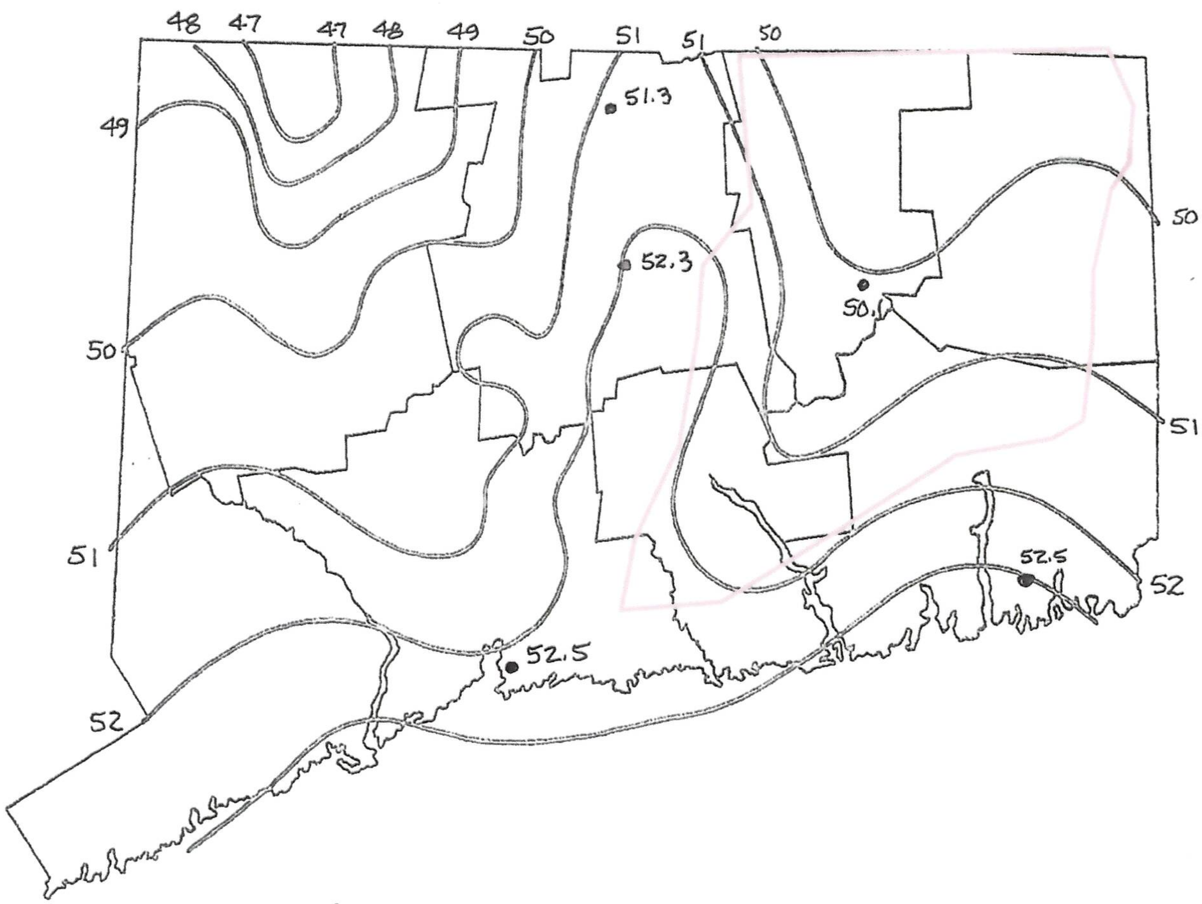

Figure 7. *Mean annual temperature in degrees F for the period 1996-2015). Our data (black dots, from Table 3) generally fit the pattern established by Brumback (1965) for data collected between 1930-1961 and thus suggest that the pattern is the same but the isotherms have increased 2-3°F. Hence, we have not changed the position of isotherms that Brumback drew using a larger data-base because only slight adjustments would be made. Notice that the central lowlands are clearly delineated by these data. We only changed the values of the isotherms. Approximate outline of proposed AVA shown in red.*

valley and coastal plain both have a more favorable ripening season than the highlands. Similarly, the highlands have recorded colder temperatures that either neighboring climatic region.

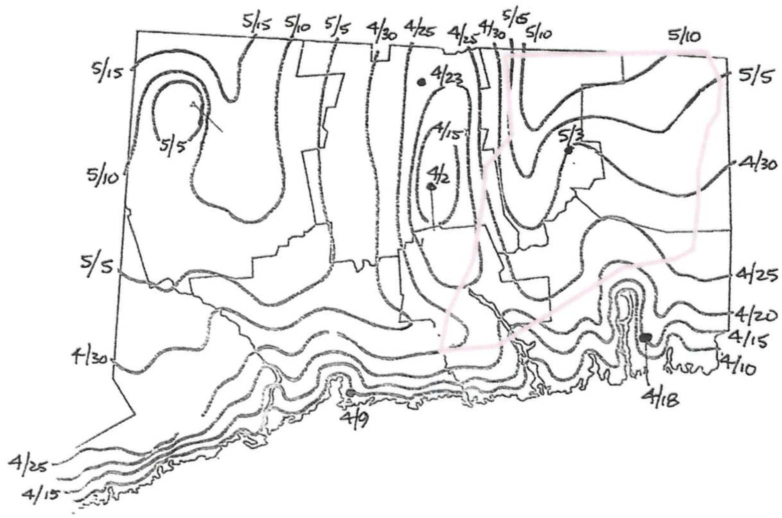

Fig. 8A Average dates of last occurrence of 32° temperature in spring

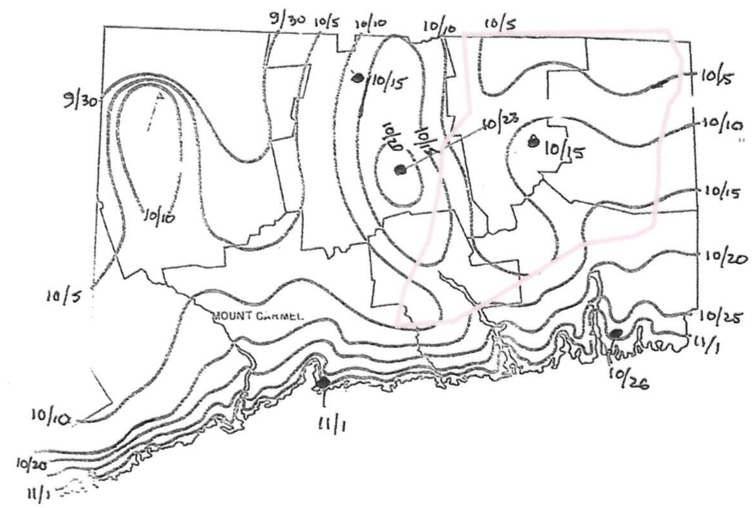

Fig. 8B Average dates of first occurrence of 32° temperature in fall

Figure 8. *A. Average last frost of spring and B. average first frost of fall. Our data (from Table 3, black dots) generally fit the pattern established by Brumback (1965)from data gathered between 1930 and 1961 and thus suggest that the pattern is the same but the isochrones have changed by about 5-6 days, earlier in the spring but later in the Fall. Hence, we have not changed the position of isochrons that Brumback drew using a larger data-base, because only slight adjustments would be made. Our data (1996-2015). We changed only the values of the isochrons. Both data sets show a steep gradient along the coastal plain and a steep gradient between the eastern highlands and the central lowlands. The time-span between those two dates (Fig. 8A and 8B) define the growing season. After Brumbach, (1965, p.43) Approximate outline of proposed AVA in red..*

These climate data have possibly greater significance for viticulture than other attributes of the proposed AVA. Heat summation in eastern Connecticut (as well as in both the central lowland and the coastal slope) is sufficient to ripen *vinifera* varieties. Cold-hardiness, however, of individual grape varieties is the prime determinant of what can be successfully grown in this region. Most *vinifera* varietals do poorly in climates with extreme cold winter temperatures or in climates with common frost in the late spring. Perusal of Table 4 and Appendix 1, Table 2 shows that most grape growers in the proposed AVA have planted cold hardy hybrids and cultivars. Cold hardy cultivars of Cabernet franc are planted in only 7 vineyards, Riesling and

Chardonnay are planted in only 6 vineyards, *Vinifera* can be grown with special care and with numerous replantings. Nonetheless, ten vineyards have not planted any *vinifera* vines. Most vineyards in the proposed AVA plant non-*vinifera* hybrids that are cold hardy, such as St. Croix, Traminette, Vidal, Cayuga, Frontanec and Vingnoles. This contrasts to the coastal region where

Table 4. Grape varieties grown in CT by region

	Coastal Region						Eastern Connecticut																	
Vineyard designation[1]	A	B	C	D	E	F	1	2	3	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Vinifera varieties																								
Chardonnay	X	X	X		X	X	X		X	X	X	X												X
Cabernet franc	X	X	X		X				X	X	X							X						X
Cabernet sauvignon	X	X																						
Riesling	X		X		X		X		X		X	X								X				X
Merlot	X	X																						
Gewurztraminer	X										X													
Muscat		X									X	X												
Gamay												X												
Zinfandel		X																						
Malbec																								
Pinot grigio		X																						
Melon de bourgogne												X												
Pinot noir	X																							X
Pinot gris									X															
Hybrid varieties																								
St. Croix		X		X				X	X		X	X	X	X	X			X						
Vignoles		X				X	X	X				X	X	X	X						X			
Seyval blanc		X				X		X						X										
Vidal blanc			X	X	X	X		X		X											X			X
Cayuga		X		X		X		X					X	X				X	X	X	X			
Traminette		X				X		X					X	X	X			X	X		X			
Chambourcin						X		X												X				
Marquette																			X		X			
Frontanec		X					X	X					X	X					X					
Frontanec gris							x	X							X									
Landot noir									X			X												X
Dornfelder									X			X												X
Baco noir							X			X										X				
Other variety[2]								X[4]				X[3]	X[4]	X[3]					X	X		X	X	

1. Vineyard designation: Numbers for Eastern Connecticut same as in Appendix Table 2. Letter designations for Coastal Region as follows: A. Chamard (Clinton), B. Gouvei (Wallingford), C. Jonathan Edwards (N. Stonington), D. Maugle Sierra (Ledyard), E. Stonington Vineyards (Stonington), F. Paradise Hills.
2. Other varieties are grown in only one vineyard; see Appendix Table 2 for information from specific vineyards
3. Sharpe Hill Vineyard and The Vineyard at Hillyland each grow different three hybrid varieties grown in no other vineyard.
4. Taylor Brooke and Cassidy Hill each grow two different hybrid varieties grown in no other vineyard

extreme winter cold and late spring frosts are rare. More *vinifera* varieties are grown in the coast al zone. Five of the six vineyards surveyed for Table 4 have *vinifera* vines producing. Cabernet franc, Merlot, Riesling, and Chardonnay are routinely grown in coastal zone vineyards. Even Cabernet sauvignon, Pinot noir, and Zinfandel are grown in some. One vineyard (Chamard) grows only *vinifera* varieties. Note also, that 10 vineyards in the highlands do not attempt to grow any *vinifera*.

Climate determines which varieties can be grown successfully and with ease at any particular location in Connecticut. Once that is said, soils become a real interest for vineyard quality.

SOILS

Soils in Connecticut are relatively young, having formed on glacial debris left after the last Ice Age glaciers that melted from 17 to 19,500 years ago (Stone and others, 2005). They developed on material that was physically broken-up bedrock. As such, they are generally fertile soils, that when not poorly drained or too rocky, support agriculture (Bell, 1985).

Connecticut was affected by the last Ice Age Glacier which covered all of the state with ice a mile or more thick. Ice that thick slowly flows, in a general southerly direction in Connecticut, and in doing so it scrapes, abrades and otherwise erodes the underlying substrate. When the glacier melted, it left all the eroded debris, called glacial till, plastered on top of the local bedrock. Some of the debris was reworked by meltwater streams and left, usually on valley sides, as piles of stratified sand and gravel. Glacial till and sand and gravel are the parent materials for most of the soils in the eastern highlands. The central valley has widespread glacial lake beds that served as the parent material for soils in that physiographic province.

The systematics of soil series of Connecticut start (Connecticut D.E.E.P. 2014) with the distinction between the parent deposit upon which the soil formed. The major distinction is between soils formed on till vs. those formed on stratified materials[2]. The most abundant (based on percent areal coverage) Connecticut soils have developed on bedrock controlled meltout (ablation) till landscapes. The soils are generally sandy loam and range from somewhat excessively to poorly drained. Locally they may be thin soils with or without many stones. Southern and western Connecticut have large areas with meltout till soils.

The second most abundant soils developed on basal (lodgement) till, material, some with a compact "hardpan" within a few feet of the surface. These soils are sandy to silty loams and may be anywhere from well to poorly drained. The hardpan may be cause poor drainage and create a perched water table close to the surface. Eastern Connecticut has the largest area of lodgement till soils and the Coastal Slope has the smallest area.

Glaciofluvial (outwash) soils area the next most abundant, but are more commonly found on the lower slopes and valley bottoms. Textures of these soils range from silt loam to loamy sand. They are almost always underlain be sand and gravel. Unless the water table is close to the surface these are well to excessively drained and may be droughty. Because of their coarse textures and high permeabilities these soils tend to have low cation exchange capabilities.

Soils formed on glaciolacustrine deposits are limited in abundance and are mostly found in the Central Valley. They are poorly drained in many places.

The composition of the underlying bedrock greatly influences the composition of the overlying till or stratified material (Robinson and Kupo, 2003 and references therein) and hence the composition of the soil also (McVey, 2006, Brown and Thomas, 2014). Final considerations for soil classification include wetness, slope, and in some cases, rockiness.

---

2. Some soils formed on alluvial sand and silt, organic material, and some marine deposits. Those soils are volumetrically minor in the Eastern Highlands.

Eastern Connecticut is mainly underlain by "schist, granite, and gneiss" (CT. DEEP, 2014) and this bedrock control on the soil type renders eastern Connecticut soils different from those of the Central Valley and western Connecticut. This is clearly shown on the generalized soil map of Connecticut (Figure 9, below). This map groups similar soil types and displays the groups spacially. Similar soil groupings are found through the Eastern Highlands and the eastern Coastal Slope. Even the western uplands have many of the same soil groupings, with a couple of added because of the calcareous bedrock. None of these soils is present in the Central Valley.

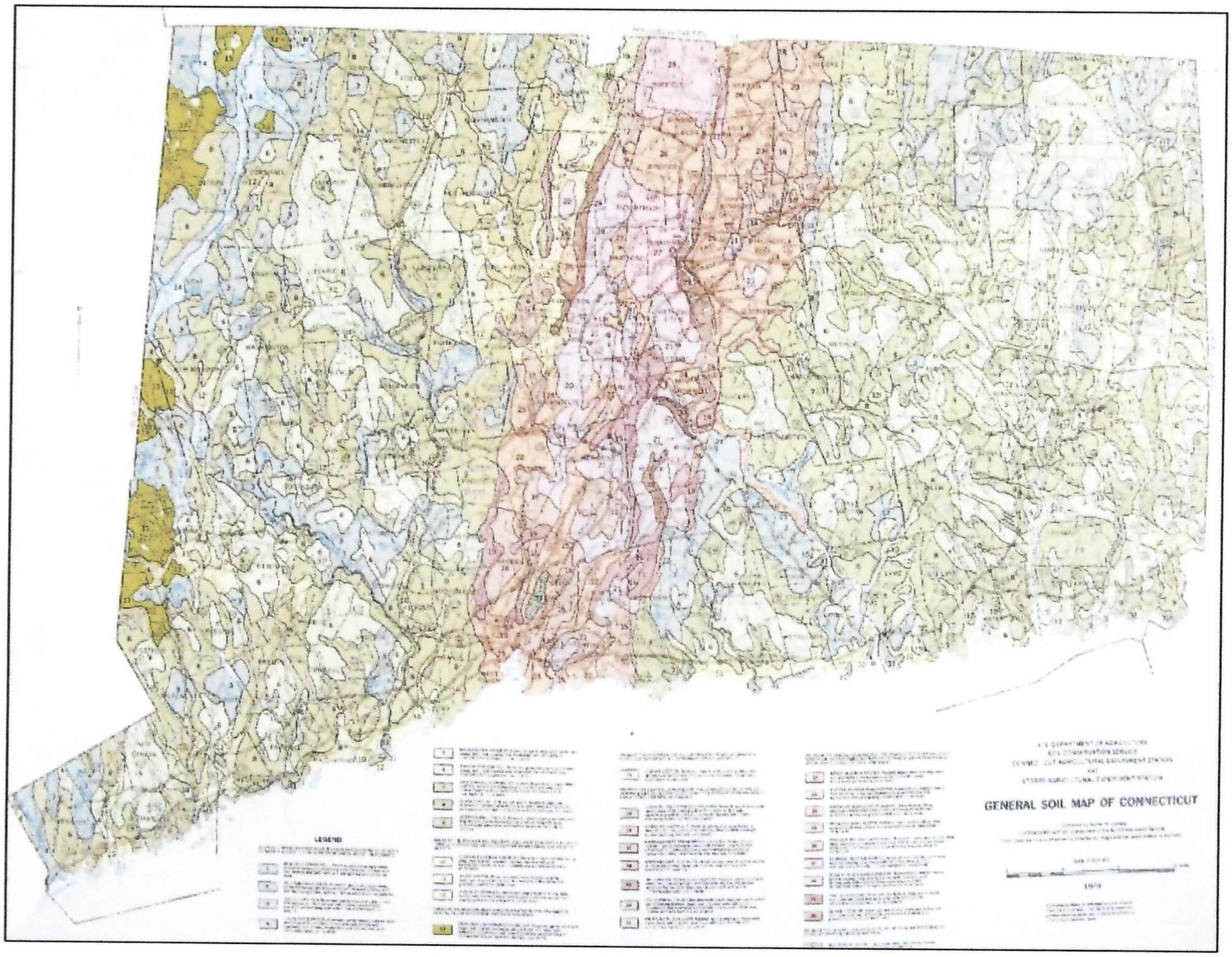

***Figure 9**. Soils map of Connecticut (Gonick, 1978). See Table 1 for explanation of colors on this map.*

Although bedrock in the Coastal Slope is similar lithochemically to that in the Eastern Highlands there are slight differences and those differences translate to slight differences in the soil associations and the chemistry of the soils. Table 5 tabulates the different soil associations. Many of the same types of soils are found in the eastern highlands, western highlands and the coastal slope. None of these soils is found in the Central Valley.

Soil chemistry. The chemistry of Connecticut soils (Brown and Thomas, 2014) is spacially highly variable as shown by the following maps and diagrams (Figs.10 and 11). One hundred (100) randomly located soil samples were analyzed for eight major and 33 minor elements. Only a few of those elemental concentrations will be discussed here: calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), phosphorous (P), sulfur (S), and zinc (Zn). The elements were chosen for discussion herein based on their importance to vine nutrition (Winkler and others,1974: Mullins and others, 1992).

Calcium inhibits iron uptake in vines and too much calcium leads to chlorosis (Goode, 2014). Iron is important to chlorophyll synthesis and also is an enzyme activator in the vine (Muller, et al 1992). Magnesium, part of the chlorophyll molecule, is involved with carbohydrate metabolism, and also activates many enzymes (Winkler, et al, 1974). The specific

Table 5. Comparison of soil associations in central and eastern Connecticut

Eastern Connecticut Highlands		Avalon Terrane		Central Valley	
Color Fig. 9	Soil association	Color Fig. 9	Soil association	Color Fig. 9	Soil association
Green	Paxton-Woodbridge	Brown	Charlton-Hollis	Pink	Elridge-Bancroft-Scitico
	Broadbrook-Rainbow		Canton-Charlton-Hollis		Windsor-Ninigret-Merrimac
Brown	Charlton-Hollis		Narragansett-Hollis		Hartford-Manchester
	Canton-Charlton-Hollis	Green	Broadbrook-Rainbow		Branford-Manchester
Yellow	Agawam-Merrimac-Hinckley		Paxton-Woodbridge		Penwood-Manchester
	Hinkley Merrimak	Gray	Hollis-Charlton	Purple	Cheshire-Wethersfield-Manchester
Gray	Hollis-Charlton	Yellow	Agawam-Merrimac-Hinckley		Cheshire-Yalesville
	Hollis-Woodbridge				Wethersfield-Holyoke-Broadbrook
	Brimfield-Brookfield				Wethersfield-Ludlow
				Mauve	Holyoke-Wethersfield-Cheshire
					Rumney-Podunk
					Hadley-Winooski

role of potassium to vine health and nutrition is not known precisely (Winkler, et al, 1974) but it helps maintain fruit acidity by exchange with hydrogen ions (Mullins, 1993). Phosphorous is part of nucleoproteins and involved with energy transport in the vines (Mullins et al, 1992). Sulfur is generally known to increase soil acidity (lower pH).

To aid the discussion several maps and diagrams made by Brown and Thomas (2014) are reproduced here (Figures 10, 11). Our discussion will be limited to the area of the proposed AVA and areas to the east, south and west of that area,

The following generalities emerge from analysis (Table 6). Soil calcium concentration is low in the central valley, west of the proposed AVA, but calcium concentrations in areas to the south and east of the proposed AVA are indistinguishable. Iron concentrations in the proposed AVA are statistically higher than in the Avalon Terrane to the east and south of the proposed AVA but are only slightly greater t han iron concentrations in the Central Valley. Magnesium

Table 6. Soil concentrations (Brown and Thomas, 2014) of some elements of viticultural interest in CT (Winkler, 1974, Mullins et al, 1992)					
Element	Figure reference	Western Connecticut	Central Valley	Eastern CT Highlands	Avalonia (E. and Coastal)
Ca	Fig. 10A,11A	1.00%	0.50%	1.00%	0.90%
Fe	Fig. 10B, 11B	3.50%	2.70%	2.80%	2.20%
Mn	Fig. 10C, 11C	700 ppm	550 ppm	500 ppm	450 ppm
Mg	Fig. 10D	0.85%	0.55%	0.62%	0.48%
K	Fig.10F	1.95%	1.65%	1.53%	1.73%
S	Fig. 11D	0.016%	0.009%	0.014%	0.015%
P	Fig. 10E	581 ppm	409 ppm	352 ppm	354 ppm
Zn	Fig. 11E	67.2	41.7	38.5	36.8
B		n.a	n.a	n.a	n.a

concentration in soils of the proposed AVA are statistically distinct from those to the south and east, but are not statistically distinguishable from those of the central valley. Potassium, concentrations are lowest in the proposed AVA. Phosphorous and zinc in the eastern half of the state are lower than in the central valley and sulfur concentration is slightly higher. Soils in the Western Connecticut Highlands tend to be higher in most of the nutrient elements than in the rest of the state. They may have less coarse (sand and gravel sized) material and organic matter which would increase the amounts recorded.

Soil chemistry suggests then that soils in the proposed AVA have the potential to be slightly more acidic and contain slightly less mineral nutrients than soils in other parts of the state. Groundwater in eastern Connecticut soils is acidic (Table 2) and rarely contains detrimental amounts of calcium; generally solute levels are low.

Discussion. The effects of soil on wine are a key component of the French concept of *gout de terroir* that for centuries has been less scientific than romantic and political. Nonetheless, it is still commonly believed that sandy soils produce delicate wines, calcareous soils produce spirituous wines, impoverished soils produce richer wines, and deep soils grow vines that best express terroir (Goode, 2014). Until recently, however, it has been difficult to find scientific justification for such statements and terroir in general (Retallack and Burns, 2016). Indeed, as recently as 2008 the following was printed in the scientific literature (Maltman, 2008, p.1), "The notion of being able to taste the vineyard geology in wine –*gout de terroir* -- is a romantic notion that makes good journalistic copy and is manifestly a powerful marketing tactic, but it is wholly anecdotal and in any literal way is scientifically impossible." Nonetheless, numerous studies are being published that document the effect of soil on the taste of wine.

For instance, Costantini et al (2012) found that soil in which Sangiovese vines grew in the Montepulciano region of Italy affected the polyphenol content of the berry skins, and both sugar and acid content of the berries themselves. Imre et al (2012) demonstrated that soil geochemistry affected the chemical and aroma profiles of wines made from Pinot noir in the Otago District of New Zealand. Basa-Cesnik et al (2015) showed that the presence and abundance of several aromatic (mostly esters) compounds in Refosk grapes of Slovenia are related to soils in which the grapes grew. Burns (2012) and Retallack and Burns (2016) showed

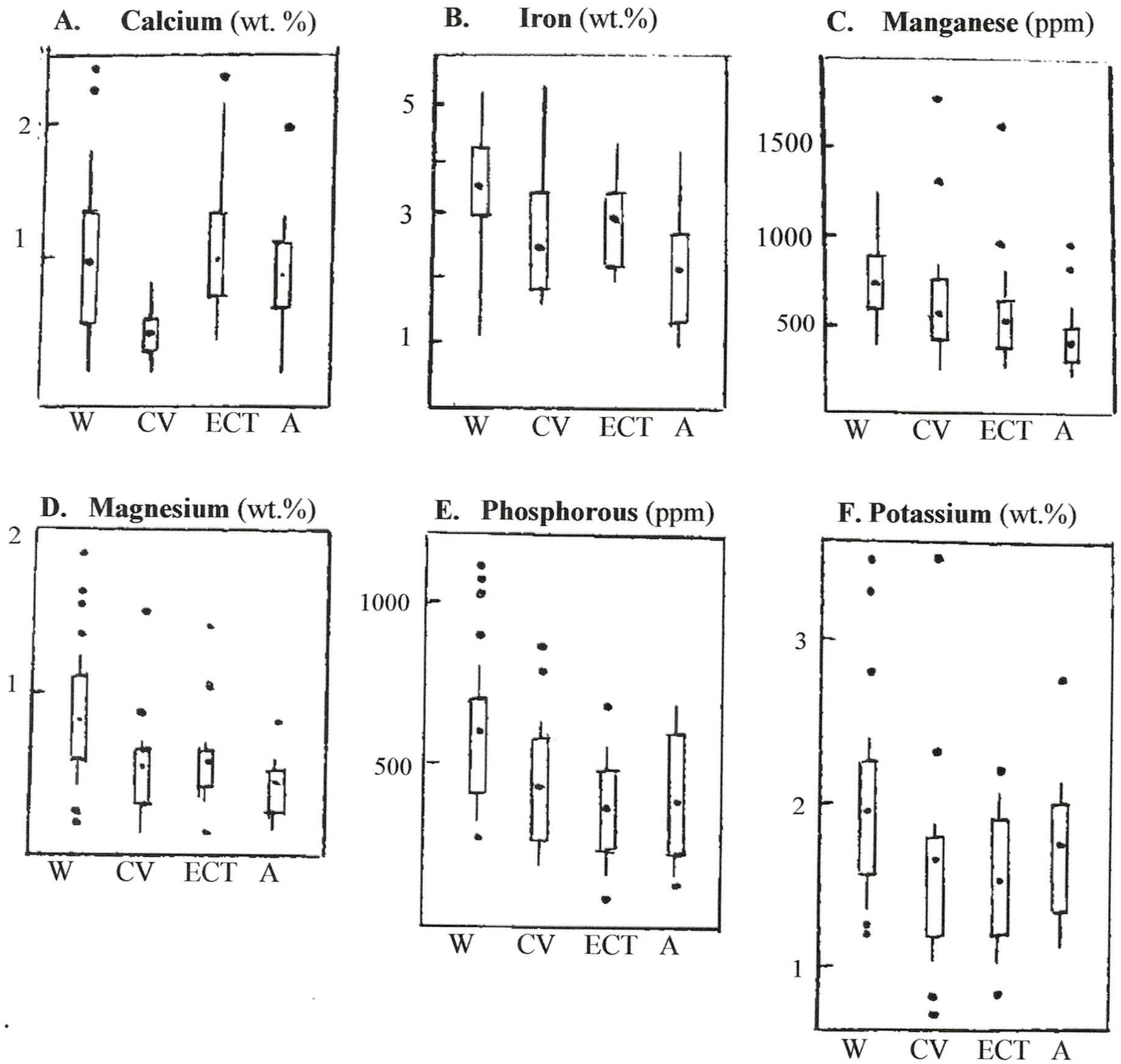

Figure 10. Distributions of concentrations of selected elements in C-Horizon soils grouped by geological provinces in Connecticut. W = Western Connecticut Highlands, part of which constitutes the Western Connecticut Highlands AVA, C = Central Valley (underlain by Mesozoic sedimentary and igneous rocks), EC = proposed Eastern Connecticut Highlands AVA, A = Avalonian Terrane which includes part of the Southeastern New England AVA.

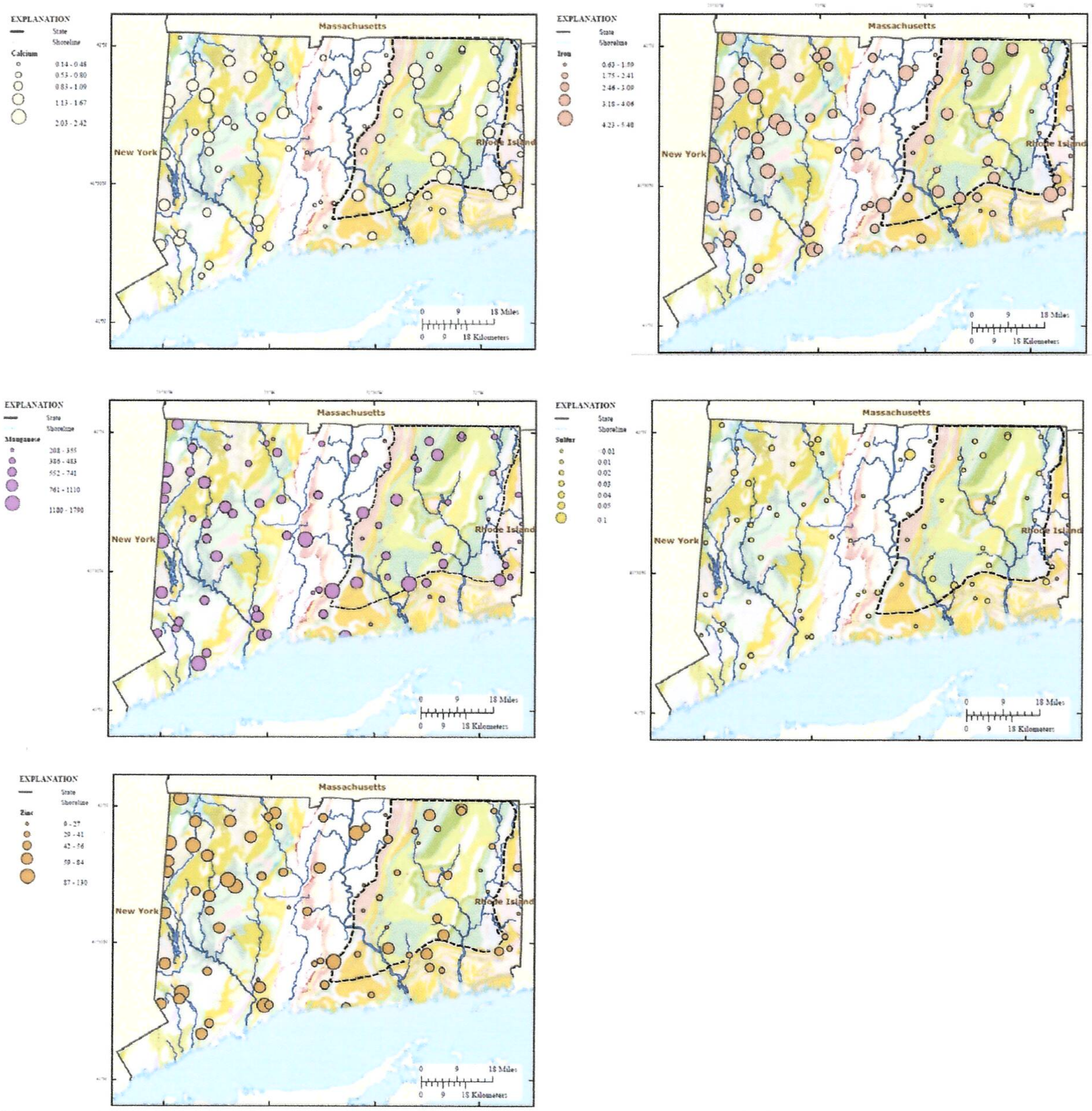

Figure 11. *Magnitude of selected elemental concentrations in C-horizon soil collection sites in Connecticut. Background pattern is the Bedrock Geologic Map of Connecticut (Rodgers, 1985) with boundaries (heavy lines) of the major geologic provinces discussed in this proposal (see Rodgers, 1985, for explanation of background patterns).*

that soil acidity and fertility of the Willamette Valley in Oregon were an important effect on the acidity of wine produced and therefore the quality of the wine.

So while it has long been held that soils are important to the growth of the vines and the quality of the juice produced, that importance is mainly because of the ability of soil to hold water (Sommers, 2008). It is only recently been acknowledged that the chemistry of soil water is derived from the soil and underlying bedrock and that that chemistry can be transferred to the wine made from grapes that grow in the soil. Those who think they can taste soil in the various may be at least partially validated...."the beauty of the soil reaches into the bottle."

Summary: Geochemical surveys of soils commonly indicate that variations in background concentrations of inorganic constituents of the soils are related to the composition of the underlying bedrock (Smith et al, 2013) and, in Connecticut, to the grain-size distribution. The dependence on underlying bedrock clearly show (Fig. 9) the soils of Central Valley stand out compared to the soils of the rest of the state. In the eastern half of the state, the bedrock control is locally important (McVey, 2006) and is related to slight differences in the regional elemental concentrations (Fig. 2, 3). The end result is that the soils of the proposed Eastern Connecticut Highlands AVA are distinct from soils to the west but have similarities to soils of the Avalonian Terrane to both the south and east. Slight differences in the areal abundance of different soil series and in elemental concentrations exist between the Eastern Connecticut Highlands and the Avalon Terrane.

We know of no scientific studies to date relating any soil parameters of Connecticut soils to any facet of viticulture or oenology in Connecticut. Nonetheless, it is tempting to suggest that the higher sulfur content of soils in the proposed AVA produce slightly lower soil pH (more acidity) and that the slightly lower mineral nutrients in the soils of the proposed AVA might help produce better structured wines made from the grapes grown in the region.

CONCLUSION

Appendix 1 tabularized the characteristics of the region in contrast to adjacent regions. Geology, one of the controlling factors in ecology, a major control of regional soil type, elevation, and climate, in Connecticut, creates a major physical basis for regionality in agriculture in general and viticulture in particular. We believe we are unique in New England in the use geology to define a proposed viticultural area. The geology determines topography, which modifies regional climates. Climate in the area is cold and most vineyards grow cold resistant hybrids. Soil and groundwater chemistry suggest acidic conditions that promote appropriate acidity in the wines.

Viticulture in this region is increasing since its commercial beginnings in the last century (Table 7). In the 1980's there were few commercial vineyards, those at Hamlett Hill being the only one associated with a winery currently known to us. Today at least 20 vineyards have been identified and we are still discovering new vineyards (Appendix 2). Our tally to date is at least (we still have not determined total acreage in several of newly found vineyards) 116 acres planted with additional acreage planned. Viticulture is ongoing, indeed, increasing, in this region and hence we believe it to be a good time to establish a regional AVA.

Table 7. Dates of first vineyard planting

Date	Vineyard designation on map	Vineyard
pre-1920	18	Joseph Preli Vineyard and Winery
pre-1980	n.a.	Hamlet Hill
1992	8	Sharpe Hill
1998	7	Priam
1999	9	Taylor Brooke
2001	11	Vineyard at Fox Run Farm
2002	2	Cassidy Hill
2005	3	Crystal Ridge
2007	10	Vineyard at Hillyland
2008	6	Preston Ridge
2009	14	Lebanon Green Vineyards
2011	1	Arrigoni Winery
2012	20	Sugar Creek
2013	17	Chestnut Hill Vineyard
2013	15	Tabor Vineyard,
2013	16	Arrowhead Acres

REFERENCES

Barrell, Joseph, 1915, *Central Connecticut in the geologic past.* State Geol. Nal. Hist Surv. of Conn. Bull. 23, 44p.

Basa-Cesnic, Helena, Bavcar, D, and Lisjak, K., 2015, Volitile profile of wine Teran PTP. Acta Agriculturae Slovenica, 105:5-14.

Bell, 1985, *The Face of Connecticut.* State Geol and Nat'l Hist Surv.of Conn, Bull 110, 196p.

Brown, Craig J, and Thomas, M.A., 2014, Major and trace element geochemistry and background concentrations for soils in Connecticut. Northeast. Geosci. 32:1-37.

Brumbach, , J.J., 1965, *The Climate of Connecticut.* State Geol. Nat. Hist. Survey of Conn, Bull. 99, 215p.

Burr, H.T., 1904, The physical geography of the Connecticut lowland. Conn. School Doc. 251, 17p.

Burns, S.F., 2012, The importance of soil and geology in tasting terroir with a case history from the Willamette Valley, Oregon., in Dougherty, P.H., ed., *The Geography of Wine: Regions, Terroir, and Techniques.* Berlin: Springer. pp. 95-108.

Coleman, M.E., 2005, *The Geologic History of Connecticut Bedrock.* Geol. Nat. Hist. Survey of CT, Spec. Pub. 2, 30p.

CONN DEEP, 2014, *Soil Catenas of Connecticut*, Conn. Dept. Energy and Env. Protection, U.S. Dept. Agri, and Nat'l Resources Conserv. Serv. Pamphlet,

Costantini, E.A.C., Bucelli, P., and Priori, S., 2012, Quaternary landscape history determines the soil functional characters of terroir. Quaternary Internat. 265:63-73.

Davis, W.M., 1898, The Triassic Formation of Connecticut. U.S. Geol. Surv. Ann. Rpt. 18, pt.2: pp.1-192

Gonick, Walter N. (compiler), 1978, *General Soil Map of Connecticut*, 1:250,000 scale. U.S. Dept. Agriculture, Soil Cons. Service,, Conn. Agri. Exp. Station, and Storrs Agri. Exp. Station.

Goode, Jamie, 2014, *The Science of Wine, from Vine to Glass.* Berkeley, CA, Univ. California Press, 216p.

Hine, A. C., 2013, *Geologic History of Florida.* Univ. Press of Florida, Gainsville, FL, 229p

Imre, S.P., Kilmartin, P.A., Rutan, T., Mauk, J.L., and Nicolau, L., 2012, Influence of soil geochemistry on the chemical and aroma profiles of Pinot noir wines. Journ. Food, Agric., and Environ. 10:280-288.

Krynine, P.D., 1950, *Petrology, Stratigraphy, and Origin of Triassic Sedimentary Rocks of Connecticut,,* State Geol. Nat. Hist. Survey of Conn, Bull. 73, 239p.

Lewis, T.R., and Harmon, J.E., 1986, *Connecticut: A Geography.* Westville Press, Boulder, Colorado.

McVey, Shawn J., 2006, Separating soil series using extractable iron and aluminum and the use of extractable iron, aluminum and pH in the separation of red soils with differing genesis in southern New England, U.S.A., unpub. M.S. thesis, Univ. of Connecticut, Storrs, 56p.

Mullins, M.G., Bouquet, Alan, and Williams, L.E., 1992, *Biology of the Grapevine.* Cambridge Univ. Press, Cambridge, UK, 239p.

Retallack, G.J., and Burns, S.F., 2016, The effects of soil on the taste of wine. Geol. Soc. Am. G.S.A. Today, 25(no.5):4-9.

Robinson, G.R., Jr. and Kupo, K.E., 2003,Generalized lithology and lithochemical character of near-surface bedrock in the New England region: U.S. Geol. Surv. Open-File Report 03-225. http://pubs.usgs.gov/of/2003/of03-225
.

Rodgers, John, 1985, *Bedrock Geological Map of Connecticut*. State Geological and Natural History Survey of Connecticut, Nat'l. Resource Atlas Series, 1:125,000, 2 sheets.

Shinn, Gene, 2013 *Bootstrap Geologist*. Univ. Press of Florida, Gainsville, FL, 297p.

Skehan, J.W., 2008, *Roadside Geology of Connecticut and Rhode Island*. Mountain Press Pub. Co, Missoula, MT, 288p.

Smith, D.B, Cannon, W.F., Woodruff, L.G., Solano, F., Kilburn, J.E., and Fey, D.L., 2013, Geochemical and mineralogical data for soils in the conterminous United States: U.S.Geol. Surv. Data Ser. 801, 19 p., http://pubs.usgs.gov/ds/801/.

Sommers, B.J., 2008, *The Geography of Wine. How Landscapes, Cultures, Terroir, and the Weather make a Good Drop*. PLUME: The Penguin Group, New York, NY, 289p.

Stone, J.R., Schafer, J.P., London, E.H., DiGiacomo-Cohen, M.L., Lewis, R.S., and Thompson, W.B., 2005, Quaternary Geologic Map of Connecticut and Long Island Sound Basin (1:125,000). U.S. Geol. Surv. Sci. Invest. Map # 2784.

Stone, Janet, and Margaret Thomas, eds., 2012, *Connecticut Terrior*. Geol., Soc. Connecticut Fieldtrip Guidebook #3, 40p

Stone, J.R., and others, 2015, *Glacial Lake Hitchcock and the Sea.* Northeast Friends of the Pleistocene, 78th Ann. Fieldtrip, Geol.Nat. Hist. Survey of Conn. Guidebook #10, 56p.

Thorson, Robert M., 2002, *Stone by Stone: The Magnificent History in New England's Stone Walls.* New York: Walker and Co., New York., 287p.

Thorson, Robert M., 2005, *Exploring Stone Walls: A Field Guide to New England's Stone Walls.* New York: Walker and Co., 187p.

Winkler, A.J., Cook, J.A., Kliewer, W.M., and Lider, L.A., 1974, *General Viticulture.* Univ. California Press, Berkeley, 710p.

Wintsch, R.P, and others, 2012, Temperature-time paths tie the tales of two forelands: The Narragansett and Hartford Basins, in Thomas, M.A. (ed) Guidebook for Fieldtrips in Connecticut and Massachusetts., Geol Soc. Am. NE Sec,; Geol. Nat. Hist Surv of Conn. Guidebook 9:C1-C32.