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Title: How Well Do American Viticultural Areas Correspond with the Soil Classes in Oregon's Northern Willamette Valley? A Question for the Wine Industry

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The specific geography of individual wine growing regions has long been understood to be a significant factor in predicting both a region's success in producing high quality grapes, and the resulting demand for wines produced from that region's fruit. In the American wine industry, American Viticultural Areas (AVAs) are increasingly being used to designate a uniqueness and specificity of place. This process is often predicated on the argument that these areas represent a certain degree of physiographic uniformity or homogeneity. This is particularly the case with regard to the phenomenon of sub-AVAs, wherein smaller areas within large, spatially heterogeneous AVAs seek to differentiate themselves based on the physiographic features that are purportedly unique to those smaller subregions. In many cases, there is a strong correlation between soil classes and AVA boundaries, whereas in other cases the correlation is not as strong. This suggests that there are factors other than physiographic homogeneity contributing to the designation of these sub-AVAs. This study employs GIS and spatial analysis to examine and potentially correlate the soil classes of Oregon's northern Willamette Valley with the sub-AVAs in that area. In doing so, this study presents maps and statistical results in order to provide a quantitative summary of the geographic context of vineyards in this region with respect to both the soil classes present and the federally designated AVA boundaries in which they are located.

How Well Do American Viticultural Areas Correspond with the Soil Classes in Oregon's Northern Willamette Valley? A Question for the Wine Industry

by

Douglas T. Wood

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Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Douglas T. Wood, Author

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Chapter 1 – Introduction

1.1 – Preamble

The system of designating American Viticultural Areas (AVAs) in the United States has been compared by many to older, more established European Geographical Indication Systems such as France's *Appellation d'origine contrôlée* (AOC) system. Within the American wine industry, the designation of AVAs has become commoditized so that wine-growing regions are increasingly divided into sub-AVAs to increase public valuation of wines produced in those areas. However, the method for defining AVAs remains somewhat elusive as factors including but not limited to soils, climate, geology, and elevation are often, but not always evenly or objectively, cited in the AVA petitioning process as factors in the federal designation of new AVAs and new sub-AVAs.

This study aims to explore soil type as a primary designator of difference or lack thereof, in the sub-AVAs of Oregon's northern Willamette Valley. Due to the relative homogeneity of climate and grape varieties grown in this region, the Willamette Valley is unique in American winegrowing regions in being able to identify the importance of soil homogeneity in AVA designation. Chapter one acts as an introduction, and will conduct a review of literature regarding the history and concept of Geographical Indication (GI) systems. Chapter one also identifies factors that have traditionally been cited as necessary for the differentiation of geographic areas within winegrowing regions. The second chapter discusses the purpose and rationale of the methodology employed, describes the data to be used, and explains the analysis that was performed. The third chapter describes the results of the analysis, and identifies distinguishing factors between the Willamette Valley AVA and its respective sub-AVAs. The fourth chapter discusses the idea that the analysis of soil type as a primary indicator of AVA designation in the Willamette Valley, illustrates the relative arbitrariness of AVA designation in this area and highlights the importance of and need for more stringent and repeatable methodologies in using this designation system in the future. The fifth chapter concludes that the AVA petition and designation process could be more transparent and objective, and could also be based more on scientifically empirical data.

1.2 – Predecessors of Geographical Indication Systems

A wine's origin of production is paramount to its identity and quality. While this is true of many agricultural products, perhaps no commodity depends so heavily on the significance of place as wine. The specific geography of individual wine growing regions has long been understood to be a significant factor in determining not only a region's viticultural success, but indeed the resulting quality of the wine produced from the region's grapes. While this relationship has been documented by geographers, philosophers, gastronomes, *vignerons*, and historians, there is a paucity of scientific research establishing a causal relationship between geographic location and wine quality. Nevertheless, Geographical Indication (GI) systems, such as those used in France, are increasingly used to substantiate and clarify the significance of geographic origin. This chapter will provide a background to the central ideas that lead to the research question of this thesis. The central ideas to be discussed include *terroir*, and Geographical Indication (GI) systems such as France's *Appellation d'origine contrôlée* (AOC) system, and the United States' American Viticultural Area (AVA) system. This background will also examine the historic and scientific basis for classifying wine-growing regions.

Since Roman times, numerous localities have established communal norms for the production of wine. These were often based on not only the geographic origin of grapes used in winemaking, but also included restrictions on the type of grape(s) used in the production of those villages' wines. The significant difference between these less formal, more localized modes of protectionist decrees and the modern concept of appellations is that the latter are an official designation and codification of winegrowing regions.

Wine has long been used as a Sacrament within the Catholic Church. Historically, the Church exerted significant influence over the production and management of European vineyards from its beginnings up until the medieval era. The dissolution of many Church-owned vineyards at the end of the medieval era, combined with the advent and increasing international popularity of Portuguese wines like Port and Madeira dramatically changed the world of French wine. The amount of economic opportunities for the international wine trade abounded at this time, as many sought to make a fortune not only within France, but in England and the United States as well (Ulin, 1996). This increase in the monetization of wine also led to a proliferation of wine fraud and adulteration techniques.

There are records of officially recognized winegrowing regions dating back to the Roman Empire, in which Rome designated regions in colonized territories as inferior to wine regions in direct proximity to Rome itself. These designations were based on protecting not only revenue, but the reputation of the wine and its region. Official government codification in the modern era, however, did not begin until the 1700's. The first such designation occurred in Italy in 1716, when the Grand Duke of Tuscany established the Chianti region and delineated the boundaries around the villages of Radda, Gaiole, and Castellina – this original boundary was further expanded in the twentieth century to become the *Chianti Classico Denominazione di origine controllata*

(DOCG), and is what is considered to be the classic Chianti region (Johnson & Robinson, 2007, Wasserman & Wasserman, 1985).

The official designation of winegrowing regions was not, however, limited to any given country. As different wines throughout France began to be better known outside of their immediate surroundings, the need to codify wine growing regions arose there as well. One of the first examples of this occurred in the *Rhône* valley in 1731, when the Gard *département* established an official group of wine villages, choosing the name *"La Côte du Rhône."* (Livingstone-Learmonth & Master, 1983, p. 24) Prior to this official regional designation, there had been a number of village-specific decrees in this area that were primarily based on highly localized protectionism. This new designation expanded that protectionist concept to a more regional scale, and effectively unified the villages into a single winegrowing region.

Many of these regions had established reputations dating back centuries, and were renowned by kings, popes, and other local nobles and elites. While outside of the traditional expanse of warm-weather Mediterranean cultural realms, one of these first officially codified regions is based mainly in modern-day Hungary, with a smaller portion extending into modern-day Slovakia. The *Tokaj-Hegyalja*, known for its amber-colored and slightly sweet *Tokaji Aszú*, was officially codified in 1737 under the royal decree of Emperor Charles VI of the Holy Roman Empire (Nyizsalovszki & Fórián, 2007).

Another notable example of official codification of a winegrowing region is that of the upper Douro Valley in Portugal. Portugal's position on the western edge of the Iberian Peninsula, its proximity to England by way of the Atlantic Ocean, and a longstanding trading and military alliance with England had developed over the centuries into a mutually agreeable wine export trade from Portugal to England by the early 18th century. Shifting alliances between England and France, as well as between England and Spain allowed for an increased share of Portuguese wine being shipped to and consumed in England. Consequently, demand outpaced supply, adulteration of wine for export increased, and more land in Portugal was planted to grapes. By the time these newly planted vineyards were mature enough to contribute to wine production, the international market faced a glut. Portugal very quickly found itself in the unfortunate position of being an undiversified economy. In an effort to control this situation, a decree was established by the *Marquês de Pombal* in 1756 which demarcated and officially codified the region within which wine labeled as Port could be grown (Read, 1982, Stanislawski, 1970).

What the four previous examples have in common, of course, is that they stand out as the first officially codified wine growing regions to be established during the 18th century in an increasingly vibrant international wine trade in Europe. While the French example of *La Côte du Rhône* in 1731 is an example of a decree established by a regional government, the first example of a winegrowing region officially codified by the French national government did not occur until over a century later.

Since the end of the eighteenth century, the French had been organizing expositions, the progeny of market festivals and the progenitor of trade exhibitions. These fairs that detailed local goods were held at irregular intervals, and were imitated throughout Europe, with the exception of Great Britain. As the world's leading industrial power, the British felt that their goods and wares did not require fairs and expositions in order to be sold throughout the world. However, in 1851, Britain held the "Great Exhibition of the Works of Industry of All Nations" in Hyde Park, which was the world's first international exhibition (Markham, 1998, pp. 7-8). The French did remarkably well, winning many awards, but "this was small consolation for the unavoidable conclusion that the glory of France's national exhibitions had been hijacked by the British in making their event international in scope." (Markham, 1998, p. 8)

In turn, the French planned to hold a Universal Exposition in 1855. Naturally, French wine would have a prominent seat at the table. The proximity of Bordeaux to England via sea trading routes, England's historical political control over the area, and Bordeaux's reputation of wine production, have long made Bordeaux a fixture in the English wine trade. The English preference for claret wine, meanwhile, tilted the market in favor of these wines of lesser quality. The growers of Bordeaux, along with Emperor Napoleon III, sought to classify their wines based on reputation and price. This classification system preceded the AOC system by many years, but was based on a similar system of geographic origin, additionally weighted with price. An influential map was drawn up by Lodi-Martin Duffour-Dubergier in 1852 to show “how individual wines came from different locations throughout the Gironde”, thus communicating “the idea that each of those on display possessed a unique character.” (Markham, 1998, p. 96) The “Wine Map of the Gironde” was the first of its kind in terms of a large-scale map of wine production, and has served as a model for effectively associating a wine’s geographic origin with its taste profile (Markham, 1998, p. 96).

On par with Bordeaux in both historical and gastronomical prestige is the French region of Bourgogne (Burgundy in English). The history of viticulture in and international notoriety of this region is well established, and is evident in the written record dating back to the Middle Ages (Baxevanis, 1987). In contrast to Bordeaux, Burgundy is comprised of much smaller vineyards, with an incredibly complex array of over 116 different appellation classifications at a fine scale (Norman, 1996). Many of these distinctions between vineyards of varying quality go back centuries, which is often reflected both in the stone walls used to divide them as well as the pattern of ownership. Similar to Bordeaux, the Burgundy region in the 1800s had already developed a reputation among European nobles and elites as a premium winegrowing region. However, the finer spatial scale at which vineyards were organized and farmed influenced the later creation of the incredibly complex appellation system known as *Appellation d'origine contrôlée* (AOC). In 1861, this centuries-old local knowledge was mapped and transformed by the Beaune agricultural committee into an officially codified winegrowing region known collectively as *"Côte d'Or."* (Fourcade, 2012, pp. 530-531)

1.3 – France's Essential Role in Codifying Wine and Place

In the middle of the nineteenth century, the North American aphid-like insect *Phylloxera* arrived in France and decimated vines throughout the French countryside, eventually leading to the near-destruction of all old vineyards (Loubère, 1978). In the 1880s, a consensus arose regarding the best approach to fighting *Phylloxera's* negative impact on vineyards. It involved the grafting of *Vitis vinifera* (Eurasian) scions onto American rootstocks, in what has become a standardized viticultural practice throughout the world. The Native American grape varieties had coevolved with *Phylloxera*, and as a result were tolerant of the pest. The genetic similarities between Eurasian and American grape species allowed for nutrient and water uptake, pest resistance, and the growth of grapes suitable for winemaking. This solution, while incredibly effective, was also incredibly expensive, and dramatically altered the playing field, particularly for the majority of vineyard owners who did not own large estates. The effect of this phenomenon has had multiple, long-lasting consequences: increased consolidation in viticulture (with large estates and Maisons buying up neighboring smaller parcels), a decline in total acres devoted to vineyards, and in combination with the prevention of fraud, the eventual establishment of the *Appellation d'origine contrôlée* (AOC) system.

The AOC system, while not officially codified until the 1920s, began around 1900 (Institute of Masters of Wine, 1970). The economic incentive for making and selling fraudulent wine had a noticeable impact on the *Champagne* region, and growers sought to prevent grapes grown outside the region from being used to make the famous wine. In 1908, a law was passed demarcating a geographic site called "*Champagne viticole*," whereby only growers within that area "retained exclusive right to the word 'Champagne' on their bottles." (Loubère, 1990, p. 114) Inevitably, some producers from the province of Champagne who had in the past put that word on their bottles were left out of the deal. Subsequent rioting ensued in 1911. In 1927, the boundaries were judiciously redrawn to include many of those vineyards initially excluded. However, that boundary was determined to be too large and, as a result, not representative of the special status of Champagne. The boundary was redrawn again in 1951, and has remained the same since.

Similar efforts at delineating AOC wine regions subsequently occurred throughout France, many of which are well-known. The common denominator, however, is not necessarily quality; rather, it is geographic origin. This system has been retooled in many other areas of the world in an effort to identify and effectively market wines. Italy, Portugal, Canada, and the United States (among others) all have similar systems in place. One main difference, however, is that the French system regulates the varieties of grapes that can be grown within any given AOC. For example, in Champagne, "grape varieties are limited to Pinot noir, Pinot meunier, and Chardonnay." (Loubère, 1990, p. 115) To clarify, if one owns a vineyard in the Champagne AOC, one cannot grow any type of grape other than the aforementioned varieties. This same highly regulated system is in place in all of France.

A vital consideration when discussing the relationship between wine and geography is the concept of *terroir*. The term *terroir*, while often used to bolster the marketing of wine and the branding of winegrowing regions, has tremendous cultural significance in France, and has been used colloquially for centuries. While not directly associated with the original GI designations in France, the term plays an increasingly influential role in AOC designation (Jackson, 1994). *Terroir* translates roughly as "a sense of place" or "of the earth/soil", but is more appropriately understood to refer to "the interaction between slope, aspect, soils, altitude, humidity, shelter and drainage, and the way in which these factors influence the critical elements of sunshine, temperature and wind, that distinguishes between the nature of wines made from different vineyards." (Unwin, 1991 p. 45) It should be noted, however, that most people would agree that *terroir* also includes "an additional dimension – the spiritual aspect that recognizes the joys, the heartbreaks, the pride, the sweat, and the frustrations of its history." (Wilson, 1998, p. 55) The relationship between *terroir* and the AOC system is not an exact fit – nevertheless, it serves as a useful way to view a wine region that is independent of the sociopolitical conception of a place.

The French *Appellation d'origine contrôlée* (AOC) designation has been used as a model for GI systems in many countries throughout the wine-growing world, including the United States, where the parallel designation is the American Viticultural Area (AVA). Both the AOC and AVA systems are nationally designated Geographical Indication systems. The highly regulated AOC system has coevolved with the cultural concept of *terroir*, which translates roughly as "of the land". While historically *terroir* referred to a small area (e.g., a village and its environs, or a grouping of vineyards), its association with the AOC system has led to its increased use in reference to larger areas (Barham 2003). This conflation between site-specific notions of *terroir* and the geography of larger-sized AOCs has spawned an effort toward redefining space in the context of wine grape growing. In Burgundy, there is currently a collective effort to redefine *terroirs* as *climats*, a smaller, more vineyard-specific geographical indication (Whalen, 2010, Robertson, 2008). This effort aims to re-establish the connection between place and product that the AOC designation no longer provides.

1.4 – The Emergence of Wine and Place in the United States

Grapes have been grown in the United States for the purpose of making wine since the Sixteenth century. Early European explorers observed a number of different Native American *Vitis* species growing up and down the Eastern seaboard (Pinney, 1989). In fact, centuries before the European settlement of North America, the Vikings made note of this when they made landfall in modern-day Newfoundland, Canada, naming it Vinland. Spanish explorers are credited with making the first wine in the United States around 1568 in Santa Elena, South Carolina (Pinney, 1989). While the species most often used for winemaking, *Vitis vinifera*, originated in Transcaucasia, the distribution of the genus *Vitis* occurs throughout the Eurasian and North American continents; there are dozens of native *Vitis* species spanning from southeastern Canada to northeastern Mexico (Mullins, et al., 1992). Among early settlers, there are many documented incidences of winemaking using these native grape species. An issue with most of these native species, however, is that they typically do not ripen to a level of sweetness suitable for traditional Old World style wines producing wines with a flavor often described as “foxy”, and as a result, many settlers sought to import, plant, and grow European *Vitis vinifera* cultivars (Pinney, 1989, p. 443).

Most prominent amongst those involved in early attempts to make wine from American-grown grapes was Thomas Jefferson. Jefferson was particularly fascinated with the potential for making wine from some of these native species, of which Scuppernong is the most notable (Pinney, 1989, Baron, 1987). In fact, this interest in Native American *Vitis* species developed in Europe at the same time, leading to the importation of American *Vitis* rootstocks to France and other countries. It is this trans-Atlantic rootstock trade that also led to the eventual spread of *Phylloxera* to Europe in the 1860s and the subsequent decimation of vineyards worldwide (Unwin, 1991).

While the practice of viticulture in the eastern United States undoubtedly played a significant role in early American history, the spread of *Phylloxera*, and the subsequent development and widespread use of *Phylloxera*-resistant rootstocks, one cannot adequately evaluate the history and importance of American viticulture without looking at the history of California and the southwestern United States. The state with by far the greatest acreage devoted to winegrowing and the largest number of both wineries and market share in the international wine industry, California has become what most people think of when discussing American wine and viticulture. The history of viticulture in California is inextricably tied to Spanish, specifically Catholic influence in the early period of European settlement. As early as 1525, Cortez had overseen the planting of grapevines in Mexico, and by 1550, viticulture had spread south into Peru, Chile, and Argentina (Mullins, et al., 1992). Spanish Franciscan missionaries planted wine grapes in Socorro, New Mexico as early as 1626 (Pinney, 1989).

The first documented instance of grapevines being planted on the west coast of North America was in 1697 when Father Juan Ugarte, a Jesuit priest, planted grapevines at a Mission in Baja California (Mullins, et al., 1992). While Spanish missionaries established the first Alta California mission of San Diego de Alcalá in 1769, there exists scant historical evidence of successful wine production until a decade later in San Juan Capistrano (Pinney, 1989). Regardless of the ambiguity associated with the historical timeline of early California mission viticulture, its importance and reputation has reached almost mythological status in California and beyond. By the time Anglo settlers began arriving in California en masse in the 1800's viticulture was well established throughout mission California, from San Diego north to Sonoma (Leggett, 1941).

Most of the production of wine in early Californian history took place in and around the Los Angeles basin, and included not only mission lands during Spanish rule, private land holdings during Mexican rule, but also private land holdings and agricultural colonies after California became a state in 1850. Some of the most well-known examples of this expansion of viticulture occurred to the east and southeast of Los Angeles proper, such as the Rancho Cucamonga and Rancho Jurupa in the 1830s and the Los Angeles Vineyard Society in Anaheim (Pinney, 1989). Other concentrations of reputable winegrowing regions began to develop in other parts of the state, most notably in Sonoma and Napa.

The earliest grapevines in Napa Valley were planted by George Yount in 1838. This area is now known as Yountville, but at that time was a Mexican land grant named Caymus Rancho (Heintz, 1999). Yount established his vineyard using cuttings taken from the Sonoma Mission, which was administered by General Vallejo, the Governor of California under Mexican rule. At that time, a handful of enterprising individuals were responsible for the expansion and development of winegrowing in northern California. One of them was a Hungarian by the name of Agoston Haraszthy. Often credited as being the “Father of California Viticulture”, a somewhat dubious title, Haraszthy purchased a vineyard in 1856 in Sonoma and immediately expanded the vineyard and set out to improve the quality of wine being made there. Haraszthy named his new estate Buena Vista, which to this day is still a functioning winery with extensive vineyards throughout the southern parts of both Sonoma Valley and the adjacent Napa Valley (Sullivan, 2013).

Viticulture and winemaking continued in California during the next century through boom and bust, including the Depression, but unlike examples in Europe, codified winemaking regions were not formalized. Much of the wine made during this time was consumed by Americans, and so did not enter into the international market. Much of that expansion occurred in the San Joaquin Valley of Central California during the 1870s, bolstered by the building of railroads and developments in irrigated agriculture (Pinney, 1989). Compared to earlier trends in California viticulture, this new expansion was far more dependent on large-scale investment (Pinney, 1989). The statistical data from that time, however limited, illustrates the boom and bust nature of the industry in California, albeit in a pattern of sustained growth over the decades (Pinney, 1989). The growth of the industry occurred in tandem with associated trades such as cooperages and brokerages, as well as patronage and research support from within the educational sector.

By the 1970's, California's reputation for viticulture and winemaking had spread throughout the world. This reputation was further cemented in 1976, when the first place award at the Paris Tasting in France was awarded to a wine from California, a 1973 Chateau Montelena Chardonnay from Napa Valley, crafted by American winemaker Mike Grgich (Taber, 2005). The Paris

Tasting was organized to coincide with the United States' Bicentennial celebration in an effort to bring attention to American wines. In addition to Grgich's wine winning first place in the white wine category, two other Napa Valley whites won third and fourth, respectively. Furthermore, Warren Winiarski's 1973 Stag's Leap Cabernet Sauvignon (also from Napa Valley) won the red wine category. This victory changed the global perception of American wine, particularly in France, and gave way to new efforts in marketing American, and specifically Californian wines to the rest of the world. Given the long association between a wine's reputation and place of origin, it seemed only natural that the United States would attempt to create its own system of Geographic Indicators to demonstrate the importance of place regarding American wine.

In 1978, the official idea of American Viticultural Areas (AVAs) was conceived, and by 1980 the first AVA (Augusta AVA, in Missouri) was established by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) (Mendelson, 2009). While Missouri does not have the reputation for premium viticulture and winemaking that California has, it does have a long history of viticulture, and is quite well-known as the birthplace of many American-bred rootstocks commonly used in contemporary viticulture (Pinney, 1989). The designation of the Napa Valley AVA followed close behind in 1981, with many others throughout the United States being added in the following decades.

Although the AVA system was initially established by the Bureau of Alcohol, Tobacco, Firearms, and Explosives, it is directly "overseen by the United States Department of the Treasury, Alcohol and Tobacco Tax and Trade Bureau TTB)." (Elliott-Fisk, 2012, p. 50) Currently, there are 213 AVAs in the United States, with new AVAs being added each year.

1.5 – Wine, Place, and Soil: The Willamette Valley as a Case Study

While admittedly imprecise in an empirical sense, the general concept of *terroir* includes many of the physical geographic influences listed in the Alcohol and Tobacco Tax and Trade Bureau's (TTB) requirements for establishing an AVA. The distinguishing geographic features required by the TTB when petitioning for an AVA are climate (temperature, precipitation, wind, fog, solar orientation and radiation, and other climate information), geology (underlying formations, landforms, and geophysical events as earthquakes, eruptions, and major flood), soils (soil series or phases of a soil series, denoting parent material, texture, slope, permeability, soil reaction, drainage, and fertility), physical features (flat, hilly, or mountainous topography, geographical formations, bodies of water, watersheds, irrigation resources, and other physical features), and elevation (minimum and maximum elevations).

The petitioning process to establish an AVA, subject to federal approval, can be a time-consuming, onerous, and bureaucratic affair, and has been known to last years before an AVA designation is approved and established. Typically, a written petition along with ancillary data is submitted to the TTB for review, and is then subjected to a lengthy process of public review and input. Earlier in the history of AVAs, this process could be rather quick and straightforward, but more recent submissions are generally more thorough and oftentimes contentious. Much is at stake, economically, and with regard to geographic identity; arguably the wine industry and the wine-consuming public are better served by this general trend toward more careful deliberation and designation. Nevertheless, the process continues to evolve, and as scientific evidence in support of AVA designation becomes more robust, so to do the AVA designations themselves (Elliott-Fisk, 2012). In some ways, the process is becoming less reliant on concepts that are difficult to quantify (such as *terroir*), and more reliant on objective, quantifiable data. While *terroir* remains an attractive and somewhat mesmerizing concept, the AVA petitioning and designation process is less conflated with that concept, particularly when considering the newer, more exacting standards expected from petitioners.

While in some regions of France this conflation between *terroir* and larger GIs is both culturally and geographically appropriate, the conflation between *terroir* and GI in other countries is problematic. For instance, the Willamette Valley AVA in Oregon, designated as an AVA in 1984, is over 3 million acres in size (Thompson, 1993). The relative lack of geographical specificity as manifested in such a large region has subsequently contributed to multiple sub-AVA petitions, in which a group of growers and wineries convincingly argue that their area deserves to be further distinguished from the larger, more geographically diverse Willamette Valley AVA (Burns, 2012). There is a parallel between the large Loire Valley growing region in northwestern France and the Willamette Valley. A recent study in France developed a methodology of combined quantitative and qualitative analysis for distinguishing the *terroir* typicality of sub-basins within the greater Loire Valley, providing a systematic means for further differentiating similar wine regions from one another without resorting to further subdivision of the Loire Valley AOC (Thiollet-Scholtus et. al., 2010). This distinction is important, because it demonstrates the disconnection between American appropriation of the AOC system and the cultural concept of *terroir*. In addition, it suggests alternative methods of differentiating multiple *terroirs* within large wine growing regions.

In the span of three years (2004-2006), six new sub-AVAs were added within the Willamette Valley AVA: Dundee Hills AVA and Yamhill-Carlton AVA (2004), Ribbon Ridge AVA and McMinnville AVA (2005), and Chehalem Mountains AVA and Eola-Amity Hills AVA (2006). The designation of sub-AVAs was not a new phenomenon: similar sub-AVA designations had occurred previously in California's Napa Valley AVA, and Russian River AVA, for example (Mendelson, 2009). The case for establishing sub-AVAs is often predicated on the idea that the larger, older AVA does not adequately represent the uniqueness of a given growing region within those boundaries. In cases such as these, petitioners make an argument for the recognition of a finer-scale sub-AVA in an effort to further distinguish their region from the larger region. The TTB requires petitioners to demonstrate that the proposed AVA is "sufficiently distinctive from the surrounding area to warrant the establishment of a new AVA." (United States Department of the Treasury, Alcohol and Tobacco Tax and Trade Bureau: "American Viticultural Area (AVA) Manual for Petitioners, 09/2012")

This thesis will explore the similarities and differences between the AVAs of Oregon's northern Willamette Valley by analyzing the correspondence between the soil order, soil series, percent clay content and parent material of the soils within each of the seven AVAs. In doing so, this study will provide a context for determining how well each of the seven AVAs correspond to the soils within their respective boundaries, ultimately answering the question of the extent to which human boundaries (AVAs) correlate to the physical boundaries of the underlying soils.

The case for studying the sub-AVAs of the northern Willamette Valley is predicated on a few salient points. The climate of the Willamette Valley

AVA as a whole does not bode well for most hot-weather grapes such as Cabernet Sauvignon, Merlot, and Zinfandel. Indeed the grape and wine for which Oregon is most well-known is Pinot noir, which is very well suited to the cool, wet climate of the Willamette Valley (Jones, et al., 2012). In the case of other AVAs that have been further divided (e.g. Napa Valley AVAs, Paso Robles AVAs, Lodi AVAs, and Russian River AVAs), climate and correlated variety-specific reputation have been used as a justification (Elliott-Fisk, 2012, Lapsley, 2007, Shabram, 1998). However, in the case of the northern Willamette Valley sub-AVAs, this distinction does not exist. They all have a reputation for growing premium Pinot noir; their distinctiveness, therefore, is predicated on the uniqueness of the soils within their respective boundaries. Despite its large size (approximately 3.4 million acres), the Willamette Valley AVA does not have a reputation as a viticultural region other than that of Pinot noir. While there is some amount of climatic variability throughout the Willamette Valley AVA and within the sub-AVAs of the northern Willamette Valley, this variability is not significant enough to allow for the production of warm and hot-weather varieties and their corresponding varietal wines. For example, the much smaller Sonoma Valley AVA (65,000 acres), comparable in size to Willamette Valley’s Chehalem Mountains sub-AVA (62,000 acres) is well-known for dozens of different varieties and their corresponding varietal wines. This includes hot, warm, and cool weather varieties (e.g. Zinfandel, Sauvignon blanc, and Pinot noir).

As a result of the Willamette Valley's sub-AVAs differentiating themselves based primarily on soil properties, the Willamette Valley provides an opportunity to ask, How well do American Viticultural Areas correspond with the soil classes in their respective regions? More specifically, how well do American Viticultural Areas correspond with the soil classes in Oregon's northern Willamette Valley?

1.6 – New Research in Wine Geography: Quantifying *Terroir*

The disconnection between physiographic features as expressed through French AOC designations and physiographic features as expressed through the AVA designation system in the United States directly pertains to the central question of "does the designation of an American Viticultural Area accurately represent the physiographic features of a wine growing region?"

While *terroir* as a cultural concept contributes to the identification, designation, and codification of official wine growing regions in France, the same is not true here in the United States. *Terroir* is often used to describe place with regard to viticultural specificity in the United States, but it does not have the longevity and resonance here that it does in France. Once can think and speak of wine growing regions without relying on or being informed by *terroir*. The wine growing regions of Italy, Spain, and other European countries are perfect examples of this phenomenon. Regardless of whether *terroir* is a consideration, other, more objective means for determining and designating official geographical status exist.

Multiple studies in wine-growing regions around the world have compared other countries' GI systems with the AOC system, and critiqued the adoption of the French GI model (Simon, 1983). In New Zealand, research has suggested that rather than merely a representation of place, *terroir* as a geographic factor has served as a regional asset in that country's standing in the global wine marketplace (Hayward and Lewis, 2008). In California, Australia, New Zealand, South Africa, Chile, and Argentina, research demonstrates that geographic processes are challenging the purported uniqueness of wine-making areas (Moran, 1993). These challenges occur in the economic realm as well, with potentially profound implications for global trade (Guthey, 2008, Josling, 2006, Hughes 2006, Broude 2005, Barham, 2003, and Jones, 2000).

In addition to the aforementioned body of literature, some researchers have attempted to statistically quantify the relationship between soil type classification and agricultural production. While not always specific to viticultural production, many of these studies included vineyards and wine-growing regions within the area of study. In seeking to understand the potential causal relationship between soil characteristics and winegrape-growing potential, more robust spatial statistical methods have been employed, particularly within the last three decades. Using information theory to analyze relationships between agricultural land use and soil survey data, Canadian researchers were able to demonstrate statistically significant correlation between the two, "indicating that land use patterns generally reflect the distribution of physical land factors." (Dumanski et al., 1987, p. 99)

Other recent research has been performed that combines robust spatial statistical analysis with geographic information system (GIS) methods. Performing their research in the eastern Californian winegrowing region of the Sierra foothills, Watkins et al. sought to demonstrate "that a statistically significant difference exists between soil and topographic characteristics of vineyard and non-vineyard sites within the study area." (Watkins et al., 1997, p. 230) This area is known for and dominated by the Zinfandel cultivar, which helped the researchers distinguish between areas with and without vineyards, as well as allowing them to limit the predictive utility of their model. While somewhat limited in its scope (the authors discuss limitations in their model due to the exclusion of variables such as elevation, other soil properties, and climatic variables), the model demonstrated its potential for future development because of its use of widely available data (Watkins et al., 1997). In study areas as large as this, exhaustive "collection of primary data is cost and time prohibitive." (Watkins et al., 1997, p. 237)

A more recent study in the Italian *Montepulciano d'Abruzzo Colline Teramane* DOCG winegrowing region employed a multivariate clustering analytical approach aided by the use of GIS. In addition, this study incorporated a combination of primary source data in the form of meteorological weather-station data and secondary data that included topographical data, geological and related soils data, and land-use data (Nuñez et al., 2011). Like Watkins et al. (1997), Nuñez et al. (2011) focused on an area known for primarily one grape, *Montepulciano*. In keeping with other similar geographic research on European viticultural areas, this study alludes to the concept of *terroir* units.

This thesis will analyze the AVAs of Oregon's northern Willamette Valley to determine to what extent these AVAs correspond with the soil order, soil series, percent clay content, and parent material of the soils within their boundaries.

Chapter 2 – Data and Methods

2.1 – Purpose and Rationale of the Methodology

Prior to pursuing a graduate degree at Oregon State University, I worked as a GIS Consultant in the wine industry, based in Sonoma and Napa, in northern California. I provided a number of services for soil scientists, viticulturalists, winemakers and vineyard managers, which included mapping existing vineyards, the mapping and analysis of soils at the vineyard-level scale and the regional scale, and assisting decision makers with regional scale geospatial analysis of a variety of viticultural data.

At the vineyard-level scale, I assisted soil scientists as they dug soil pits on both existing and potential vineyard sites. In some cases, older vineyards had declined in productivity, and were slated to be replanted. In other cases, a given site had not yet supported viticulture, but was being considered for viticultural development. I employed Global Positioning System (GPS) and Geographic Information System (GIS) technology to aid soil scientists and viticulturalists to sample these sites, using GPS to guide and log the location of soil pits in a gridded format, and GIS to combine that geospatial data with the soil sample results in order to map the soil physics and chemistry of the site. The resulting geospatial data were used by a consortium of scientists to make planting recommendations, which included rootstock, clone, and grape variety selection, drainage tile and terrace locations, vineyard row direction, and vineyard block breaks that corresponded with different soil characteristics. At the regional scale, I assisted geographers, wine lawyers, vineyard owners, and winemakers in preparing soil maps and other data to successfully petition the TTB for American Viticultural Area designation of winegrowing regions throughout California. The maps often included climatic, geologic, and historical data from other collaborators.

Through my experiences, I became aware of the high level of importance placed specifically on soil classification within the AVA petitioning process. At the regional level, soil series were an index by which a region was determined to be distinct from other regions. Whereas in some cases, climatic variability or micro-climatic variability could be the differentiating factor in AVA designation, in other cases soil was the primary distinguishing characteristic. In discussing the primacy of climate versus soils with regard to viticultural suitability, a former colleague noted that in the context of Sonoma Valley, Napa Valley, and Solano County's Green Valley (which are adjacent valleys running from north to south in Sonoma, Napa, and Solano counties, respectively), that the main distinguishing feature was more climatic in nature than soils. For example, as one travels from West to East through these adjacent valleys, summer temperatures can increase substantially through each valley. In contrast, Oregon's Willamette Valley does not have a comparable climatic variability. I argue that in this context, soils are a more important distinguishing factor than climate in the Willamette Valley. Therefore, this method of reasoning is regionally specific. As a larger question for the wine industry, this then begs the question of whether the AVA classification system, as it stands, is appropriate/comprehensive/transparent in communicating to the public, the actual differences in produced wine, as is commonly understood.

When discussing the hierarchy of my decision making process, I was influenced by a number of *terroir*-related concepts described in a paper published in 2002 by Emmanuelle Vaudour. In Vaudour's paper "The Quality of Grapes and Wine in Relation to Geography: Notions of *Terroir* at Various Scales," a number of figures were included in an effort to describe the various hierarchies involved in conceptualizing not only *terroir* but also mapping winegrowing regions. Arguing that the mapping of winegrowing regions at a larger scale should be modelled using a scheme of *terroir*, the author suggests with regard to research on the geography of viticulture that "the main problem is that data on climates and soil properties are seldom modelled spatially; even when they are so recorded, the spatial modelling of *terroir* is often difficult because the hierarchy of the data is unclear or may change from one viticultural region to another. The spatial level appropriate for each variable has to be defined." (Vaudour, 2002, p. 132) I have included Vaudour's figure "Relationship between the amount of map units and the mapped area extent in 27 *terroir*-related studies" to demonstrate a hierarchy of scales within geographic studies of viticultural regions. I have also included Vaudour's figure "Adapted concept of viticultural *terroir*, aimed at mapping" to demonstrate the hierarchy of climate versus soils in informing my decision to focus on soils as a distinguishing factor between sub-AVAs in the Willamette Valley.

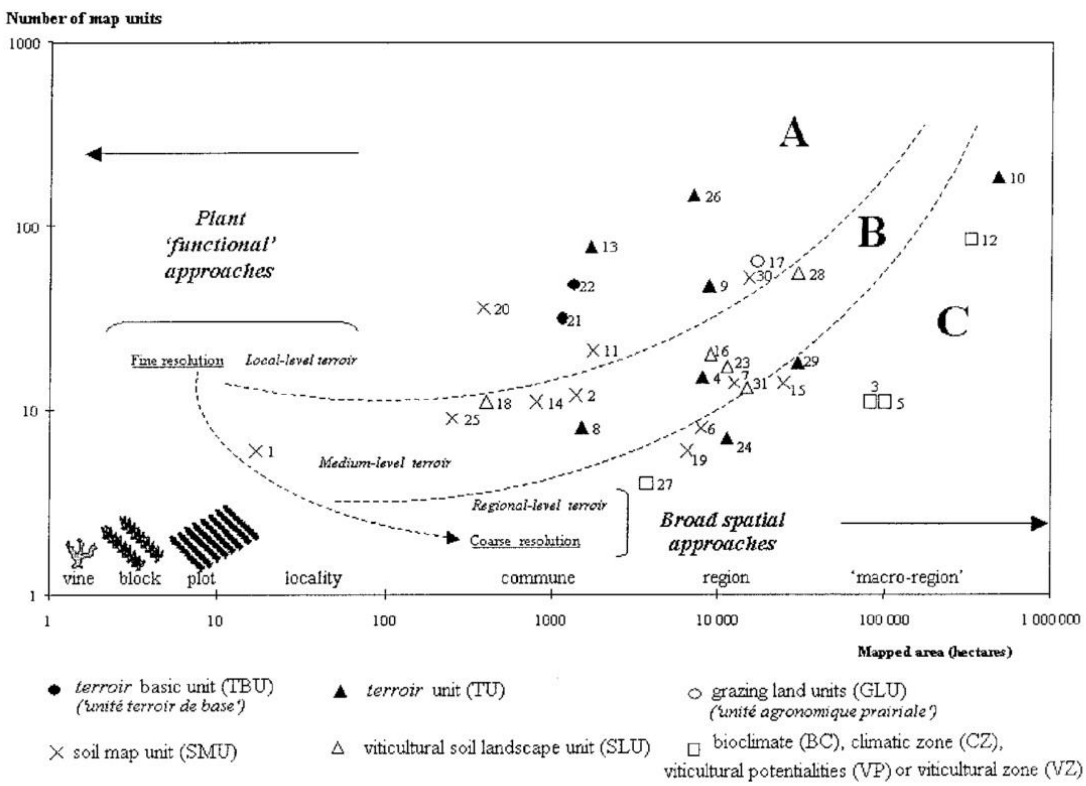

Figure 2. Relationship between the amount of map units and the mapped area extent in 27 *terroir*-related studies.

Figure 2.1a – Relationship between the amount of map units and the mapped area extent in 27 terroir-related studies (Vaudour, 2002)

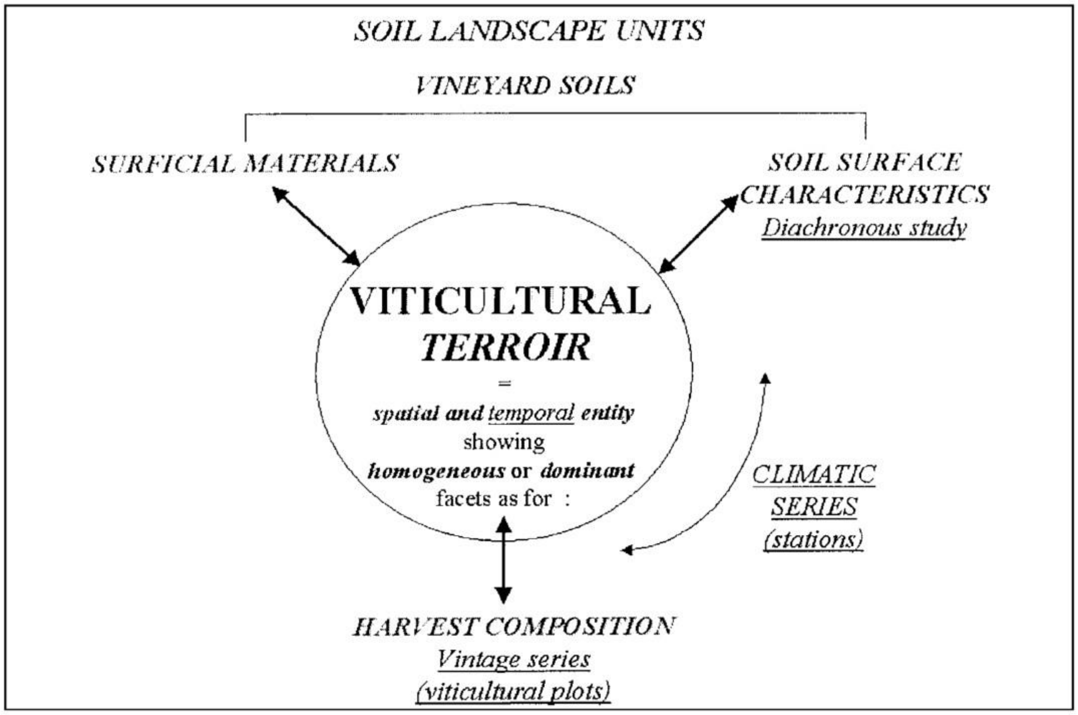

Figure 4. Adapted concept of viticultural *terroir*, aimed at mapping, by Vaudour (2001).

Figure 2.1b – Adapted concept of viticultural terroir, aimed at mapping (Vaudour, 2002)

In gauging the relative homogeneity and heterogeneity of soil characteristics, two factors must be taken into account: the first is the inherent complexity of soils. The second is hierarchies of scale when discussing soils over a large area or region. With regard to discussing the homogeneity and heterogeneity of soils over a large region, I have chosen to focus on a small number of soil characteristics: clay content as a proxy for water-holding capacity and respective regions' soil's order. Given the sheer number of soil series over a large study area such as this, approaching this question at that scale would lead to the conclusion that these regions are heterogeneous. In contrast, focusing on the order of soils not only makes the data more intelligible/approachable, but will be less misleading with regard to soil homogeneity and soil heterogeneity. Grapevine health and viticultural suitability are less dependent on the qualitative nature of soil series names and can be better gauged at this regional scale by focusing on soil order as a delimiting factor.

2.2 – Natural Resources Conservation Service (NRCS) SSURGO data

The vineyard-level mapping process included creating preliminary maps based on Soil Survey Geographic database (SSURGO) data in a GIS format. SSURGO data is prepared and administered by the Natural Resources Conservation Service (NRCS), a branch of the United States Department of Agriculture (USDA) which was established in 1935 in response to the devastation caused by drought and subsequent soil erosion during the Dust Bowl era. Tasked with maintaining agricultural productivity, the NRCS (originally named the Soil Conservation Service) partners with local communities and private farmers to prevent soil erosion and promote sustainable farming practices. Part of that mission includes mapping soils throughout the United States on a county by county basis. One of the resulting products of these mapping efforts is the Soil Survey Geographic database (SSURGO), which is compiled and distributed in a GIS and tabular format via the Web Soil Survey website (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm). The data set is based off of field sampling and interpolation of landscape and is notoriously inaccurate at a fine scale. However, at a coarse scale (i.e. greater than 1:24,000), it serves as a good reference and indicator of the general soil properties of a given location.

SSURGO data is often used for preliminary planning purposes when making agricultural decisions regarding site suitability, erosion control, and with regard to viticulture, rootstock, variety and clone selection. SSURGO data is also often used in decisions related to land-use permits at the county level, particularly on steep slopes or highly erodible soils. As previously mentioned, because of its well-known inaccuracies in the field, property owners, viticulturalists, winemakers, and vineyard managers will sometimes hire soil scientists to perform on-site analysis by digging soil pits, taking samples, and sending those samples to a soil analysis laboratory in order to more accurately assess the physical and chemical properties of the soil. Even in cases where this is done at the scale of two to three soil pits per acre, there can be incredible variability on a given site.

For the purpose of coarser scale landscape interpretation and the mapping of American Viticultural Areas, SSURGO data are indispensable. Indeed, the AVA petitioning process requires SSURGO data be used in delimiting proposed AVA boundaries. For this reason, and because this study's area of research is so large, SSURGO data was used for analysis. Because the Willamette Valley AVA straddles the nine Oregon counties of Benton, Clackamas, Lane, Linn, Marion, Multnomah, Polk, Washington, and Yamhill, and the NRCS SSURGO data is released at a county level, SSURGO GIS shapefiles and data tables were downloaded and aggregated into a master data set. The resulting shapefile contained approximately 100,000 individual records, each representing a contiguous polygon of a soil type. The NRCS Soil Data Viewer (a third party application designed to work in conjunction with ArcGIS) was used to populate the master shapefile with corresponding data including soil series name, parent material, taxonomy (soil order), percent clay content, percent organic matter, hydrologic soil group, frost free days, drainage class, representative slope, and available water storage at depths of 0-25cm, 0-50cm, 0-100cm, and 0-150cm.

2.3 – American Viticultural Area (AVA) data

While working as a GIS Consultant in the wine industry, I also had the opportunity to familiarize myself with the geospatial intricacies of American Viticultural Area data. As previously mentioned, I was instrumental in providing maps and data for the AVA petitions on numerous projects. In addition, I digitized dozens of existing AVA boundaries into a GIS shapefile format for use in our mapping services to clients. These boundaries were of great interest to winemakers, viticulturalists, wine realtors, and vineyard developers, particularly when they needed to determine the AVA provenance and/or locality of a given vineyard or development site. Through this work, I became intimately familiar with the AVA boundary descriptions provided online by the Federal government, and the techniques required to transform those text-based descriptions into a GIS format.

For this study, the AVA boundaries of the Willamette Valley were digitized into a GIS shapefile format using descriptions listed on the Federal TTB website. The metes and bounds for each AVA in the United States are listed in intricate detail, and use 7.5 minute United States Geologic Survey (USGS) topographic maps as an ancillary reference. Digitizing the AVA boundaries required that a digital copy of each listed USGS topographic map be obtained. Approximately 30 maps were needed, and a Python script was developed in order to automate the download process and data management of the files. The script read the federal Alcohol and Tobacco Tax and Trade Bureau website where AVA metes and bounds are listed, scanning for each instance of “Quadrangle, Oregon” within the 200+ AVA descriptions. The script then retrieved all of the quad names that preceded “Quadrangle, Oregon", and used those quad names to find corresponding latitude/longitude codes within a CSV file (e.g. Corvallis = 44123e3). The script then spliced the latitude/longitude code into three parts (e.g. 44123e3 -> 44123, e, 3). At that point, the script accessed the state-run Oregon Geospatial Data Clearinghouse FTP site, and used the spliced code to extract all of the necessary USGS Quad ZIP files. The script then unzipped all of the ZIP files, and renamed the .TIF and .TFW files with the corresponding quad name. As a final step, the script batched the "Build Pyramids" function within ArcToolbox.

Each AVA was hand digitized based on its respective description on the TTB website. AVA boundaries are based on natural features, human features, township and range boundaries, and in some cases, latitude and longitude coordinates. Natural features include, but are not limited to, watershed boundaries, ridge lines, bodies of water, and elevation contours. In the case of bodies of water, which are primarily rivers, streams, and creeks, interactive digitizing was performed using the USGS topographic maps. In the cases of watershed boundaries, ridge lines, and elevation contours, a 10 meter resolution Digital Elevation Model was used to calculate and create contour lines at the appropriate scale and elevation. Those elevation lines were then clipped out of the resulting shapefile to match the metes and bounds, and the AVA shapefile(s) were digitized using the snap-to-feature editing function in

ArcGIS. Human boundaries include roads and highways, administrative boundaries such as National Forest boundaries, Bureau of Land Management boundaries, private property boundaries, counties, and municipalities. In some cases, these human boundaries are readily visible on the USGS topographic maps. In other cases, these boundaries were obtained in a digital GIS format from a variety of government websites and data portals, and were subsequently used as the reference in a snap-to-feature edit. In the case of township and range boundaries, a digital GIS shapefile based on the Public Land Survey System (PLSS) was obtained from the state-run Oregon Geospatial Data Clearinghouse, and the AVAs were digitized using the snap-to-feature edit function. The PLSS system was developed after the Revolutionary War as a way to describe and subdivide land. While not quite as accurate as the more recent satellite-derived Latitude and Longitude Degrees Minutes Seconds (DMS) system that Global Positioning Systems (GPS) use, the PLSS is more often used in legal descriptions of land and parcel boundaries. In the case of the PLSS system in western Oregon, it is primarily based on the Willamette Meridian and the Willamette Baseline, which intersect just west of downtown Portland.

Once the AVA shapefiles were created, the corresponding SSURGO data for each AVA (Willamette Valley, Dundee Hills, Chehalem Mountains, Ribbon Ridge, McMinnville, Eola-Amity Hills, and Yamhill-Carlton) was extracted from the nine-county SSURGO GIS shapefile using the clip function in ArcGIS. The resulting AVA-clipped versions of the SSURGO data were then analyzed using a variety of different methods. The combination of non-point data (polygons), three-dimensional heterogeneity at a fine scale, and incredibly large numbers of soil series names made statistical analysis at such a coarse scale very difficult. In lieu of this, percent clay content was chosen to serve as a proxy for analyzing soils and determining their relative degrees of spatial heterogeneity. Percent clay was specifically chosen because it is a valuable predictor of viticultural suitability and is often correlated with a given soils water holding capacity. Given the paucity of research on this particular topic with regard to human-constructed Geographic Indicators, many statistical approaches were used. In particular, many of the new tools within ESRI's ArcGIS newly released Spatial Statistics Toolbox were explored and experimented with in order to determine their usefulness in analyzing the SSURGO data. The tools that were explored included Grouping Analysis, Geographically Weighted Regression (GWR), Hot Spot Analysis, Anselin Moran's, Global Moran's I, and Ordinary Least Squares. Given the recent release of these Spatial Statistics tools, there was very little in the way of existing literature to aid in research questions. Fortunately, one of the main developers of this ESRI extension was available for consultation, and made many suggestions. Unfortunately, none of the statistical methods explored actually produced useful data. Perhaps with more time and consultation, these methods could be further explored in the future with more substantial results. Map examples of some of these methods, including Anselin Moran's and Hot Spot Analysis, have been included in an appendix. Ultimately, the decision was made to revert back to the initial analytical methods used with the SSURGO data that produced substantial results. The results of this geospatial analysis will help describe how well the AVAs in the northern Willamette Valley correspond to the soil order, soil series, percent clay content, and parent material within their boundaries.

Chapter 3 – Results

3.1 – Correspondence between AVA boundaries and selected soil characteristics

This chapter will provide an explanation of the results generated in the geospatial analysis of AVA boundaries and their underlying soil characteristics. The soil characteristics to be explored are soil order, soil series, percent clay content, and parent material.

3.2 – Results: Willamette Valley American Viticultural Area

The soil taxonomy of the Willamette Valley AVA, represented by soil order in Figure 3.1a, is largely heterogeneous. Nine of the twelve different soil orders are present within the 3,430,170 acre Willamette Valley AVA: Alfisols, Andisols, Entisols, Histosols, Inceptisols, Mollisols, Spodosols, Ultisols, and Vertisols. Given the overall soil diversity in the state of Oregon, this is not that surprising. There are general patterns of distribution and concentration of these soil orders within what is a very large AVA. As seen in both Figures 3.1a as well as the corresponding soil order figures for the sub-AVAs (Figure 3.2a – Figure 3.6a), there are significant concentrations of Alfisols, Mollisols, and Ultisols within all six of the Willamette Valley sub-AVAs. In addition, there are smaller portions of Inceptisols within some, but not all of the sub-AVAs. Lastly, there is a very small presence of Vertisols within the Eola-Amity Hills AVA.

Due to its large size, the Willamette Valley AVA lacks a dominant soil series. In terms of area, the largest soils series present within the AVA is the Woodburn silt loam, 0 to 3 percent slopes, comprising a mere 4.11% of the total area of the AVA. The inherent soil diversity in the Willamette Valley AVA, as represented by both soil order and soil series makes this result rather unsurprising. Of interest, however, particularly in contrast to the Willamette Valley sub-AVAs, is the relatively high percentage of area represented by Mollisols. Mollisols make up 39.96% of the total area of the Willamette Valley AVA, which is due in large part to the lasting effects of the Missoula Floods. The other large portions of coverage are represented by Ultisols (23.58%), Inceptisols (15.5%), and Alfisols (13.51%). The majority of the soil series are mapped as having 20-50% clay content (Figure 3.1b).

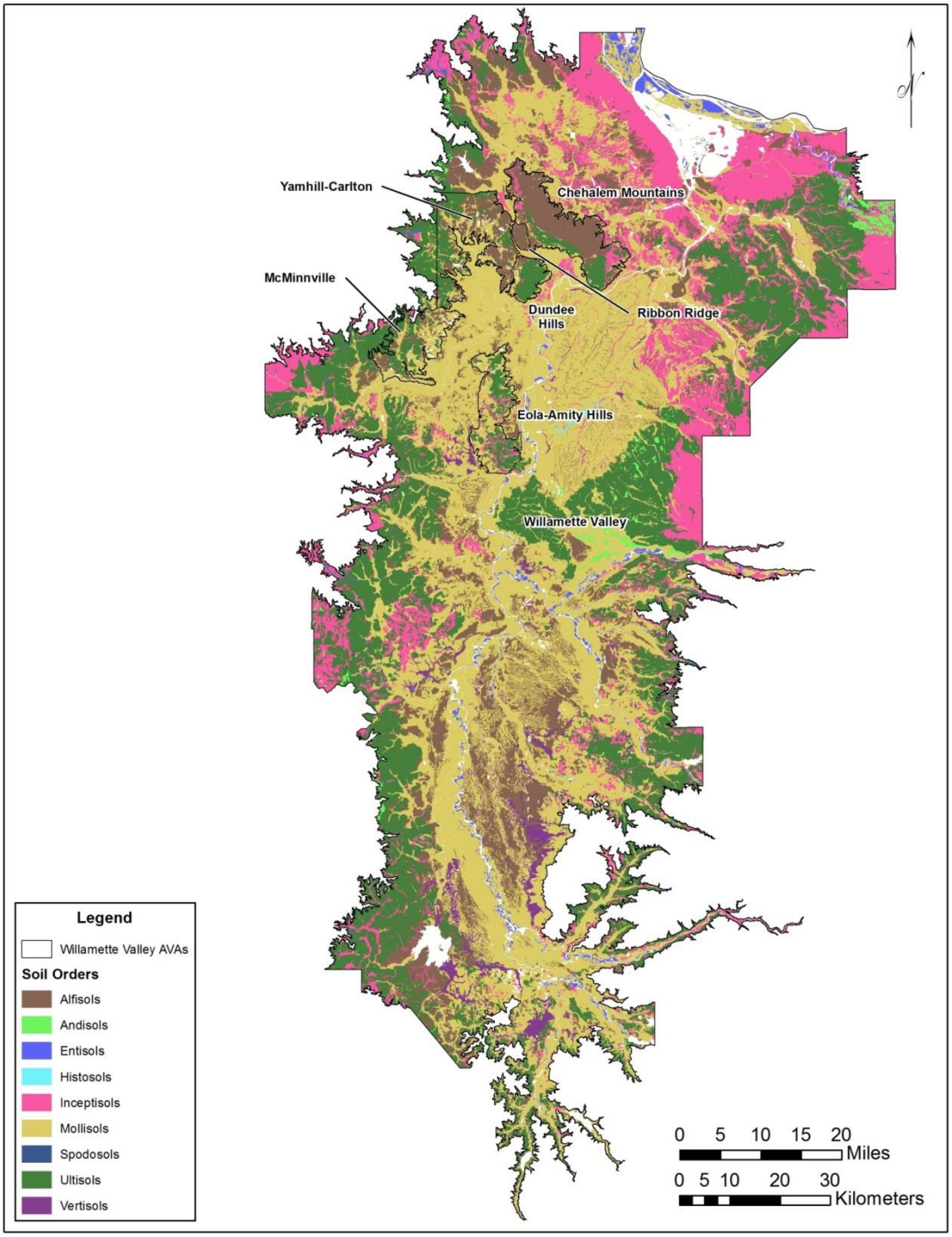

Figure 3.2a – Soil Orders of the Willamette Valley American Viticultural Area

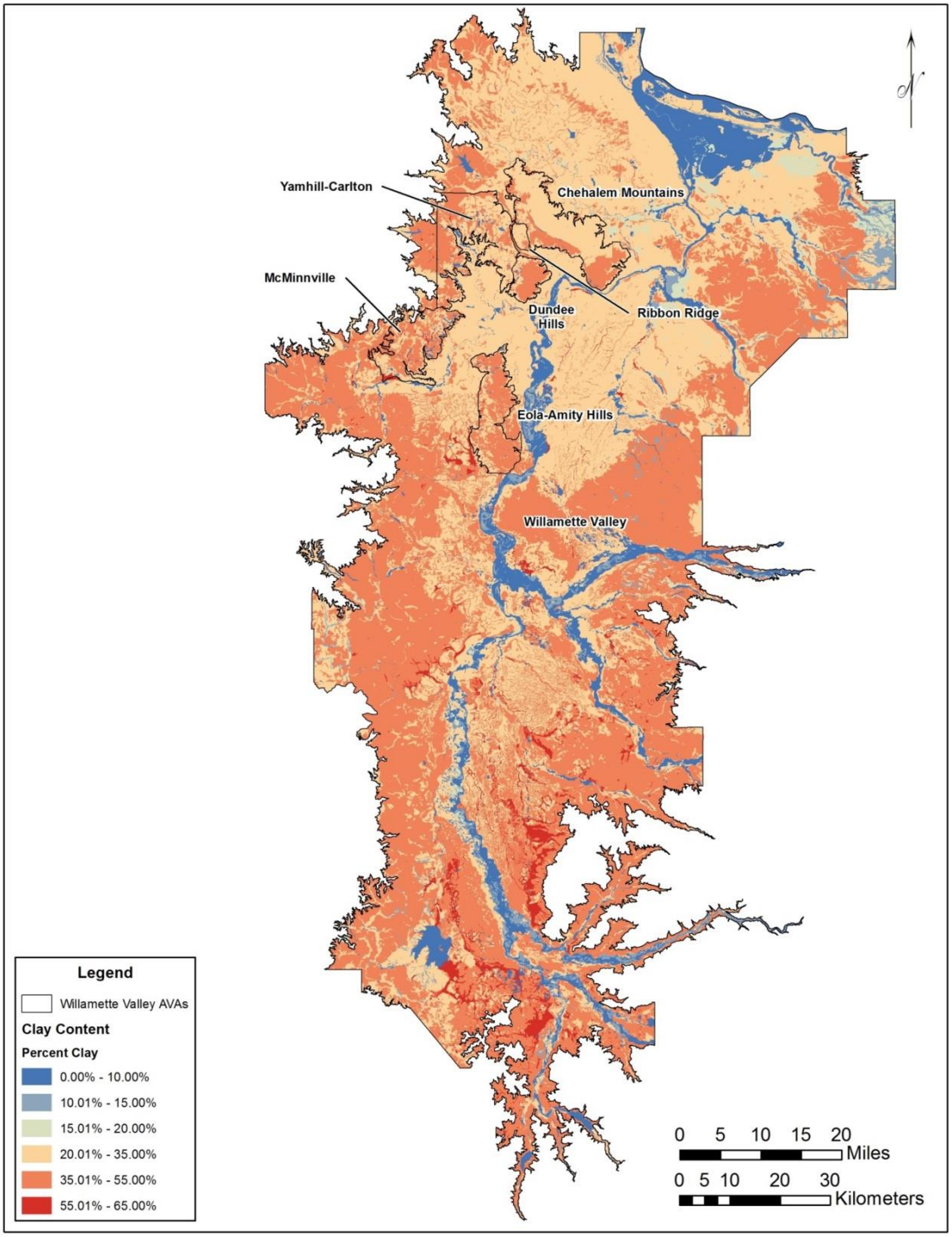

Figure 3.2b – Clay Content within the Willamette Valley American Viticultural Area

3.3 – Results: Chehalem Mountains American Viticultural Area

The Chehalem Mountains AVA, at 62,336.9 acres, is the largest sub-AVA in the northern Willamette Valley. It is also the northernmost of the sub-AVAs and is located approximately 15 miles southwest of downtown Portland. With regard to soil order (Figure 3.2a), the Chehalem Mountains AVA is clearly dominated by Alfisols, which represent 64.78% of the total area. The remainder of the AVA is comprised of Ultisols (17.68%), Mollisols (9.44%), and Inceptisols (7.49%). As the name connotes, the Chehalem Mountains AVA is on elevated terrain.

The Chehalem Mountains AVA is dominated by the Laurelwood soils series, which comprise over 40% of the soils in the AVA. The Jory soil series, Oregon's state soil and often credited with being ideal for viticulture, comprises the next largest percentage within the AVA, at approximately 15% of the total area. The parent material of the Laurelwood series is largely comprised of loess, and also colluvium derived from basalt and sedimentary rock. The majority of the soil series are mapped as having 20-30% clay content (Figure 3.2b).

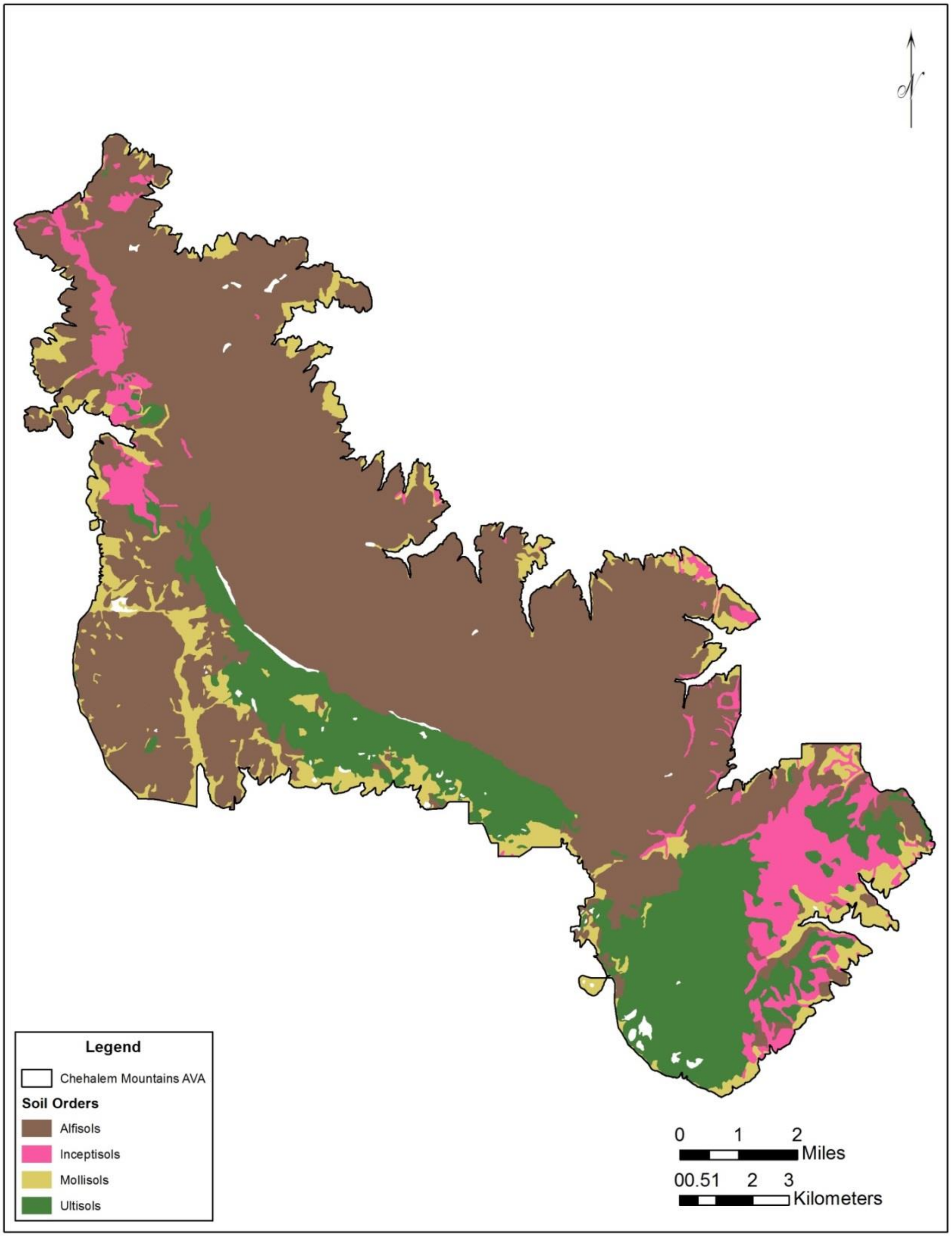

Figure 3.3a – Soil Orders of the Chehalem Mountains American Viticultural Area

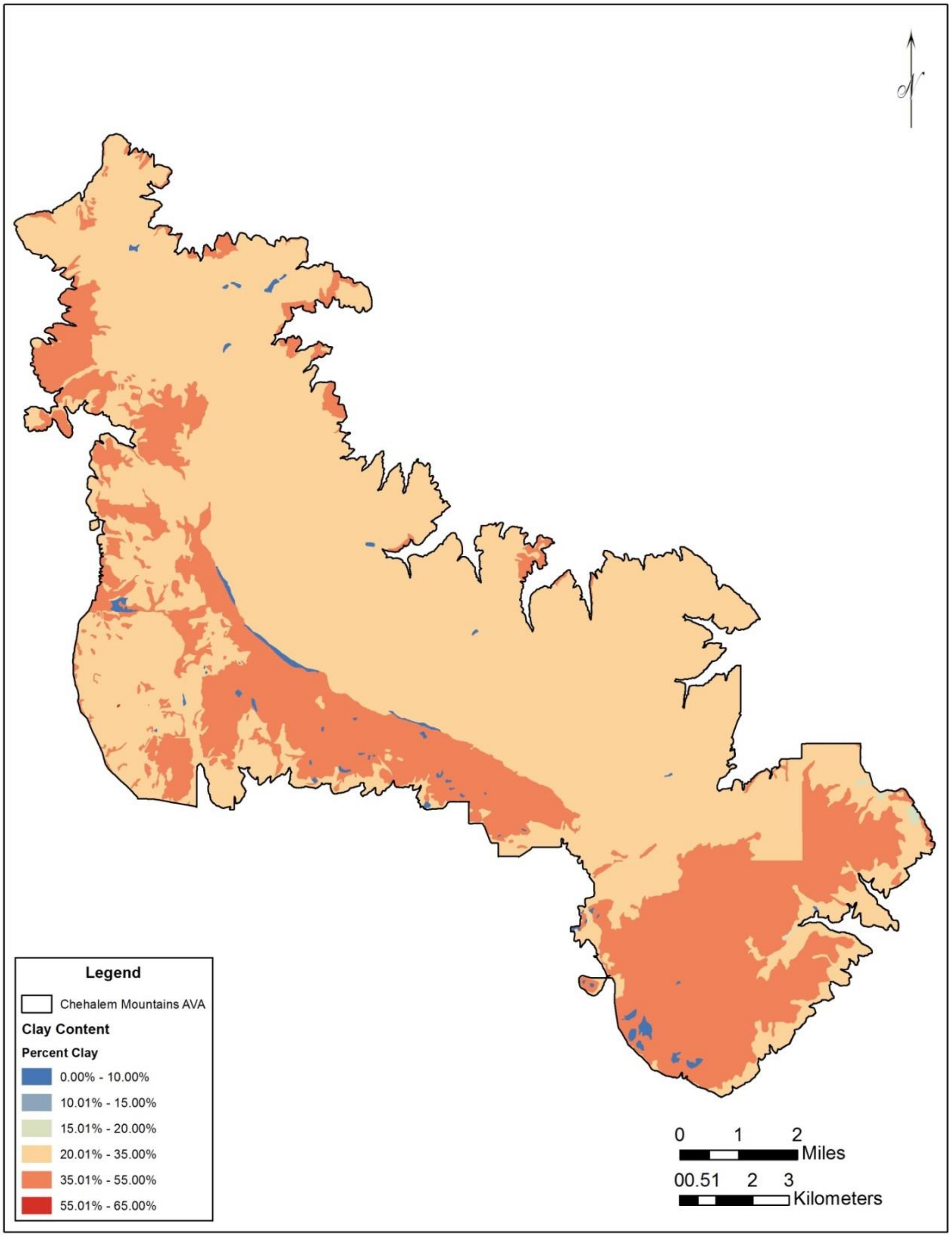

Figure 3.3b – Clay Content within the Chehalem Mountains American Viticultural Area

3.4 – Results: Ribbon Ridge American Viticultural Area and Dundee Hills American Viticultural Area

The Ribbon Ridge AVA, at 3,489.53 acres, is the smallest sub-AVA in the northern Willamette Valley. It is also completely encompassed by, and occupies the southwestern corner of Chehalem Mountains AVA. As a result, it is not only a sub-AVA of the Willamette Valley AVA, but also a sub-AVA of the Chehalem Mountains AVA, thus making it a sub-AVA within a sub-AVA. With regard to soil order (Figure 3.3a), the Ribbon Ridge AVA is like the Chehalem Mountains AVA, dominated by Alfisols, which represent 87.94% of the total area. The remainder of the AVA is comprised primarily of Mollisols (11.31%), with a much smaller percentage of Ultisols (0.71%).

The Ribbon Ridge AVA is dominated by the Willakenzie soil series, which comprises over 78% of the soils in the AVA. The remainder is comprised of the Dupee soil series (13.8%), with smaller amounts of Wapato, Chehalem, Panther, and Carlton soils. The parent material is comprised of almost 90% colluvium derived from sedimentary rock. Over 90% of the soil series is mapped as having 30-40% clay content (Figure 3.3b).

The Dundee Hills AVA, at 12,424.3 acres, is the second smallest sub-AVA in the northern Willamette Valley, and is approximately one mile south of both Ribbon Ridge and Chehalem Mountains AVAs. With regard to soil order (Figure 3.3a), the Dundee Hills AVA is dominated by Ultisols, which represent over 60% of the total area. The remainder of the AVA is comprised of Mollisols (22.2%) and Alfisols (16.22%).

The Dundee Hills AVA is dominated by the Jory soil series, which comprise 58.34% of the soils in the AVA. The remainder is comprised of Chehalem, Panther, Woodburn, Willakenzie, and Nekia soils. The parent material is largely comprised of colluvium derived from basalt and sedimentary rock. The majority of the soils (60%) are mapped as having 40-50% clay content with almost 40% of the soils mapped as having 20-40% clay content (Figure 3.3b).

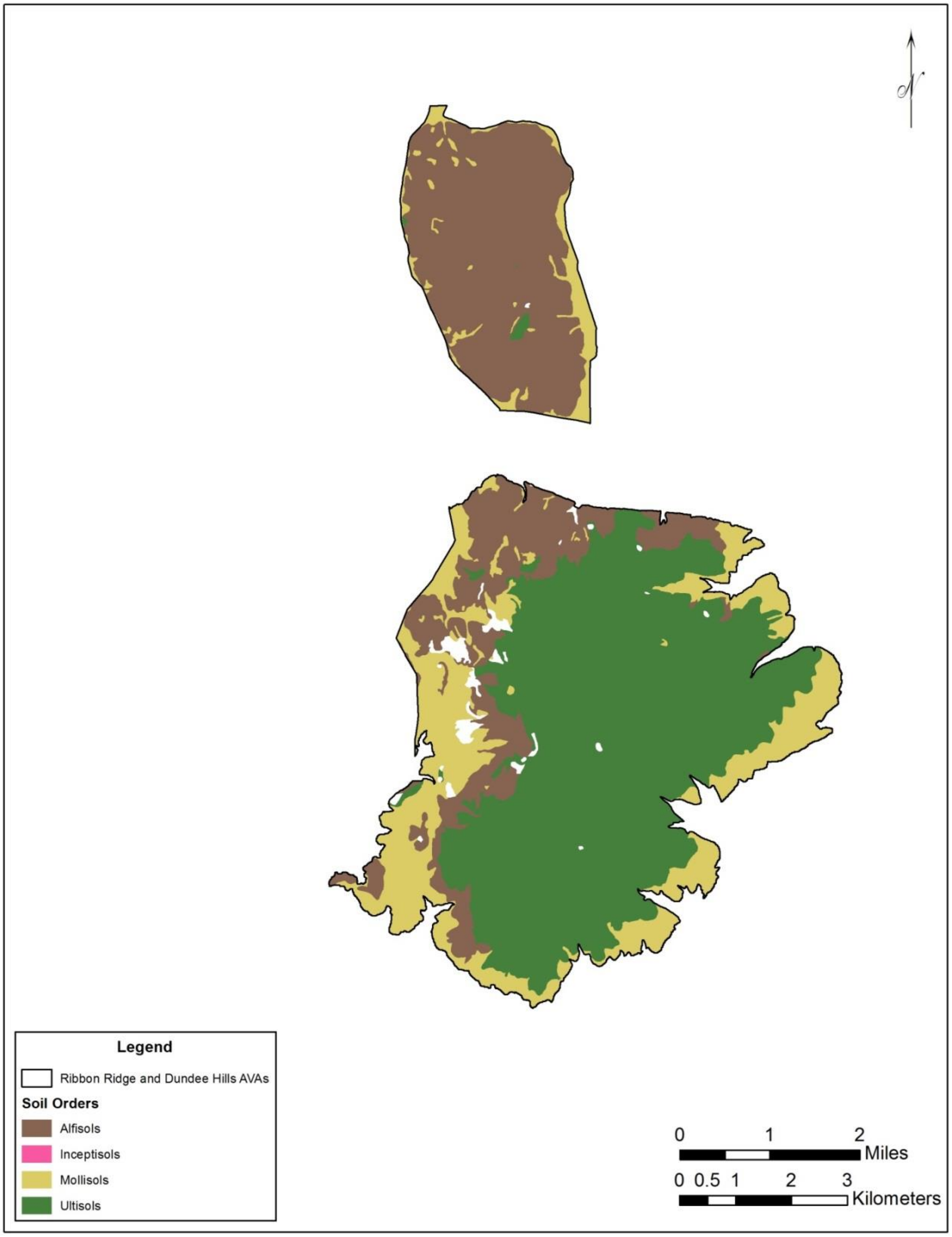

Figure 3.4a – Soil Orders of the Ribbon Ridge and Dundee Hills American Viticultural Areas

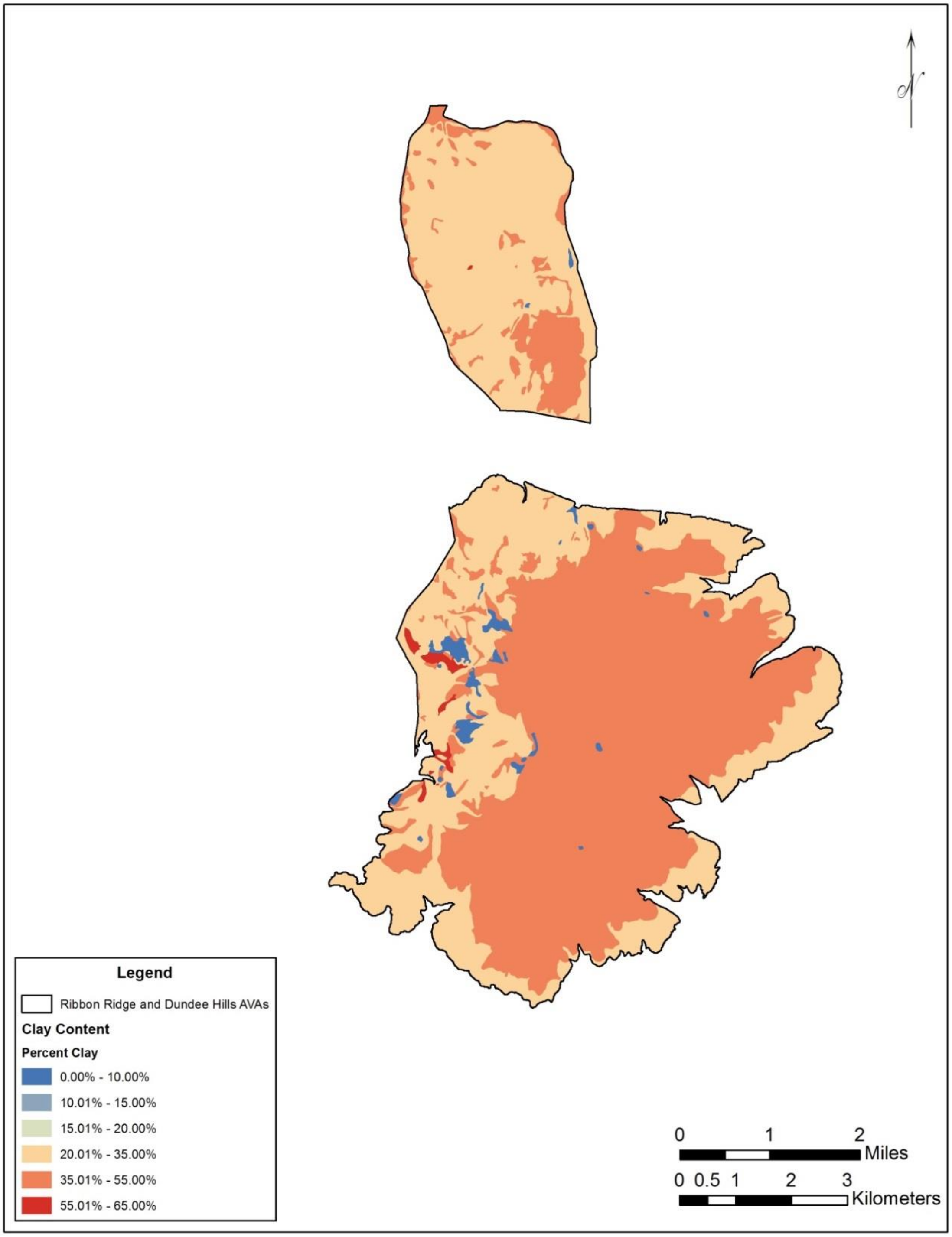

Figure 3.4b – Clay Content within the Ribbon Ridge and Dundee Hills American Viticultural Areas

3.5 – Results: Yamhill-Carlton American Viticultural Area

The Yamhill-Carlton AVA, at 56,759.5 acres, is the second largest sub-AVA in the northern Willamette Valley. It is located due west of, and is directly adjacent to, the Chehalem Mountains, Ribbon Ridge, and Dundee Hills AVAs, and wraps around a low-lying valley floor. With regard to soil order (Figure 3.4a), Alfisols comprise the largest percentage of the total area at 44.79%. The remainder of the AVA is comprised of Mollisols (27.73%) and Ultisols (26.76%). Unlike the Chehalem Mountains AVA, the Ribbon Ridge AVA, or the Dundee Hills AVA, there is no dominant soil order.

The Yamhill-Carlton AVA's largest soil series is the Willakenzie soil series, which comprises 38.46% of the soils in the AVA. The remainder is comprised of the Peavine series (19.75%) and Woodburn series (18.71%), with less than ten percent each of the Jory, Wapato, Hazelair, and Chehalem soil series within the total area of the AVA. The parent material is largely comprised of colluvium derived from sedimentary rock and basalt. The majority of the soil series are mapped as having 30-50% clay content (Figure 3.4b).

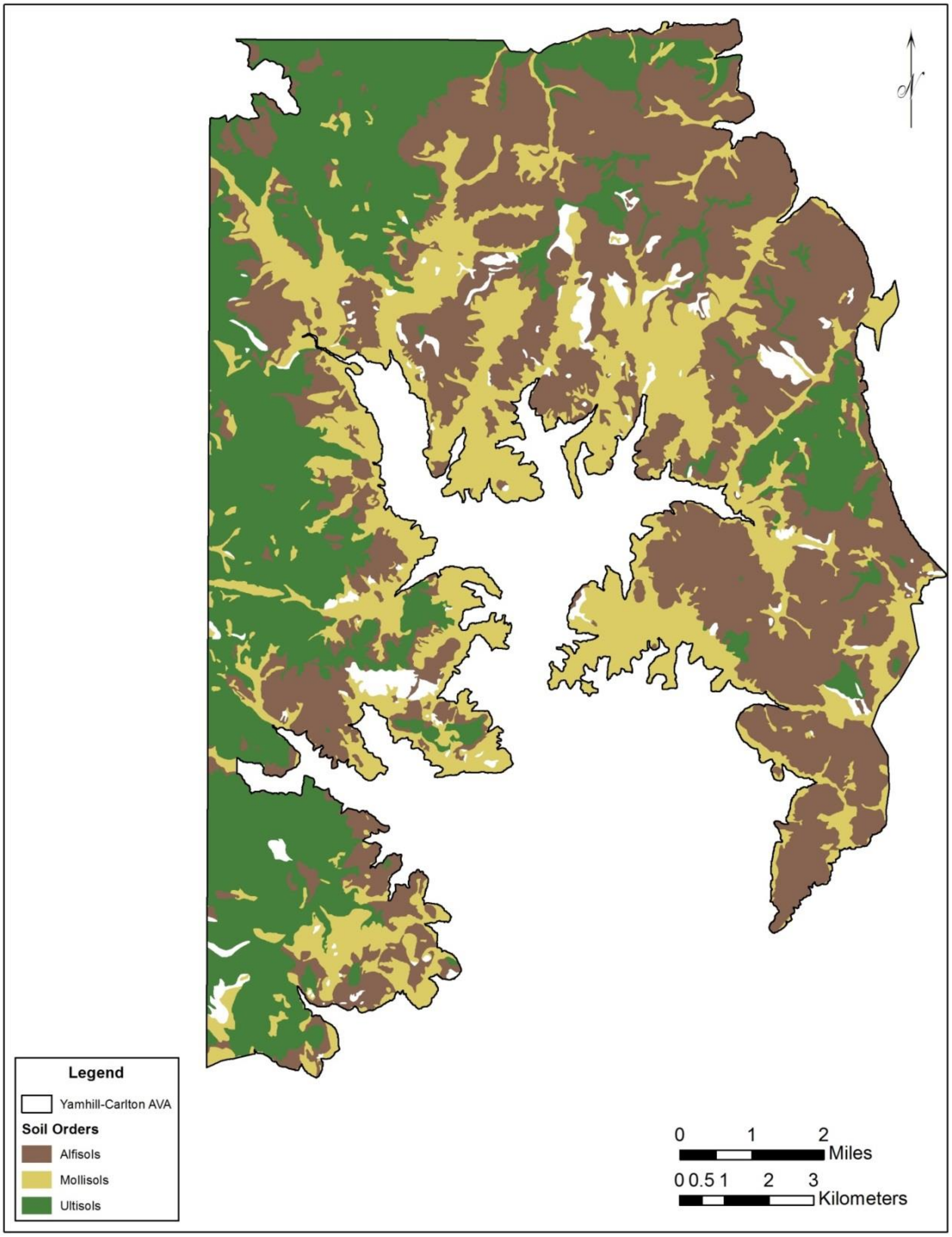

Figure 3.5a – Soil Orders of the Yamhill-Carlton American Viticultural Area

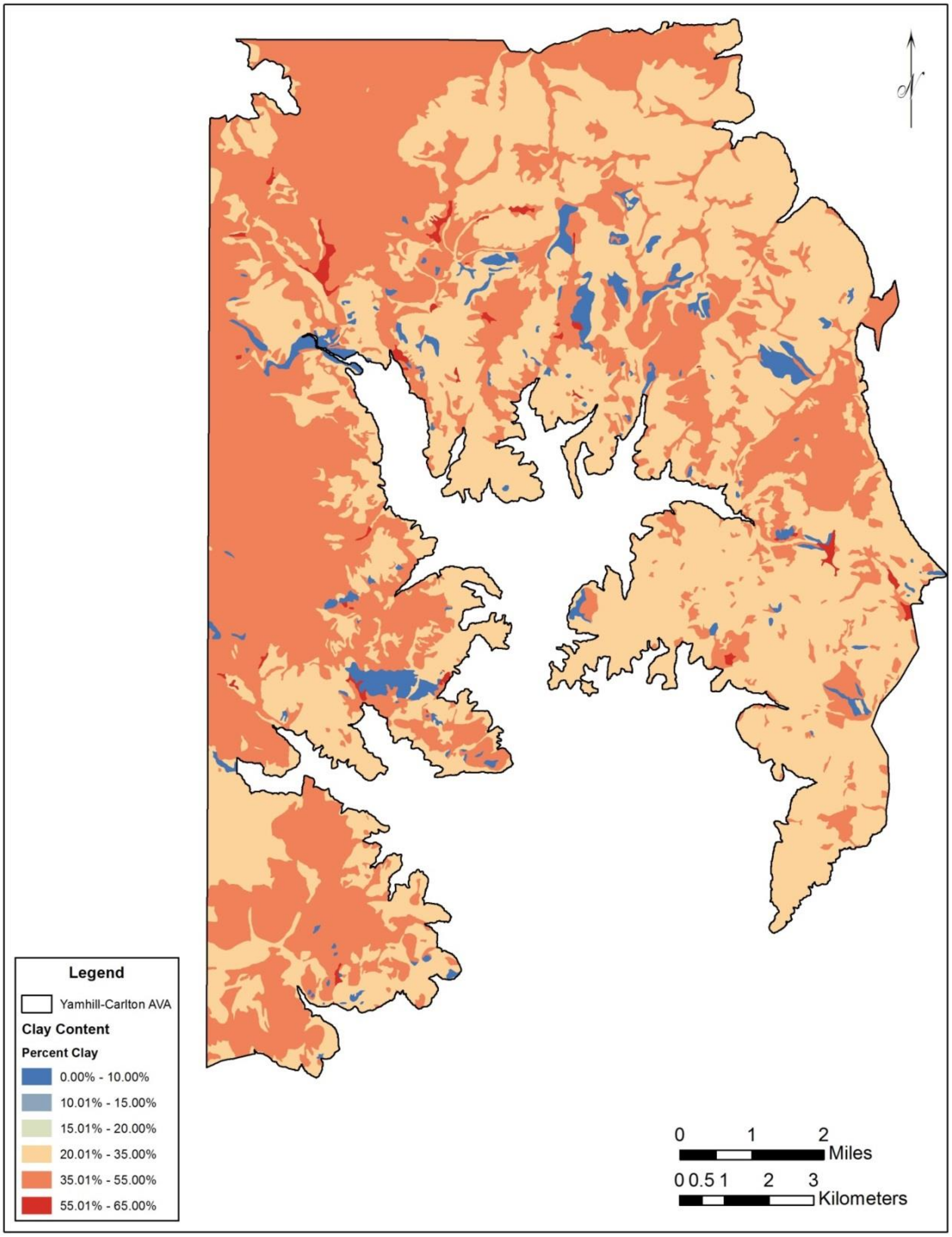

Figure 3.5b – Clay Content of the Yamhill-Carlton American Viticultural Area

3.6 – Results: McMinnville Viticultural Area

The McMinnville AVA, totaling 36,432.5 acres, is located southwest of, and shares a small border with, the Yamhill-Carlton AVA. With regard to soil order, (Figure 3.5a), no one soil order is dominant. Mollisols comprise the largest percentage of the total area at 41.83%. The remainder of the AVA is comprised of Ultisols (30.98%), Alfisols (22.23%), and Inceptisols (1.32%). Even more so than the Yamhill-Carlton AVA, there is not a dominant soil order within the McMinnville AVA.

The McMinnville AVA contains significant amounts of Willakenzie, Jory, Yamhill, and Peavine soils, but no one soil dominates. The largest soil series is the Willakenzie series, which comprises 21.65% of the soils in the AVA. The remainder is comprised of the Jory series (14.5%), the Yamhill series (14.21%), the Peavine series (13.36%),and the Steiwer series (5.42%), with an additional 30% comprised of a mishmash of different soil series including Chehalem, Cove, Panther, Carlton, Olyic, Hazelair, Amity, and Willamette, all under 5% respectively. The parent material is largely comprised of colluvium derived from sedimentary rock and basalt. The majority of the soil series are mapped as having 30-50% clay content (Figure 3.5b).

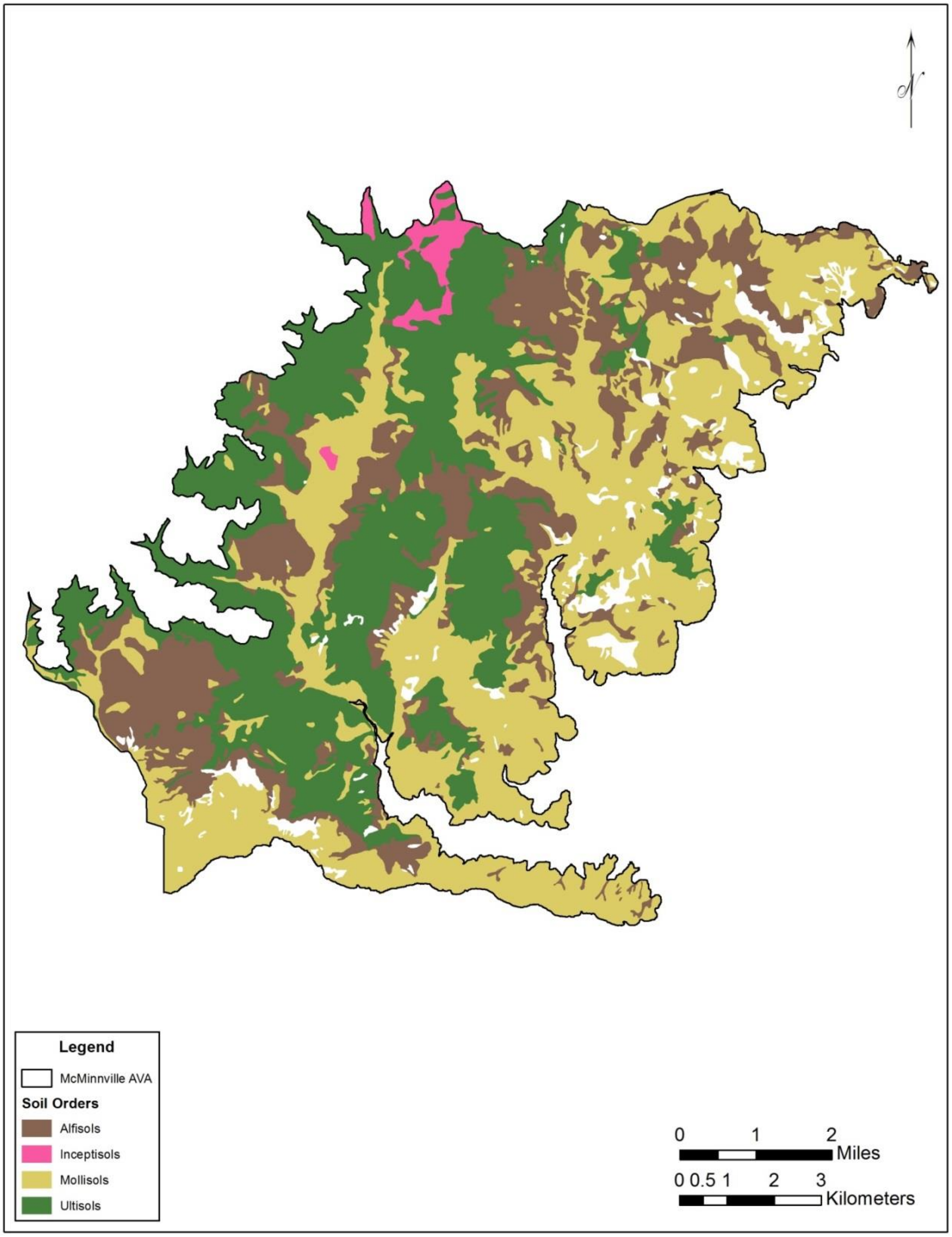

Figure 3.6a – Soil Orders of the McMinnville American Viticultural Area

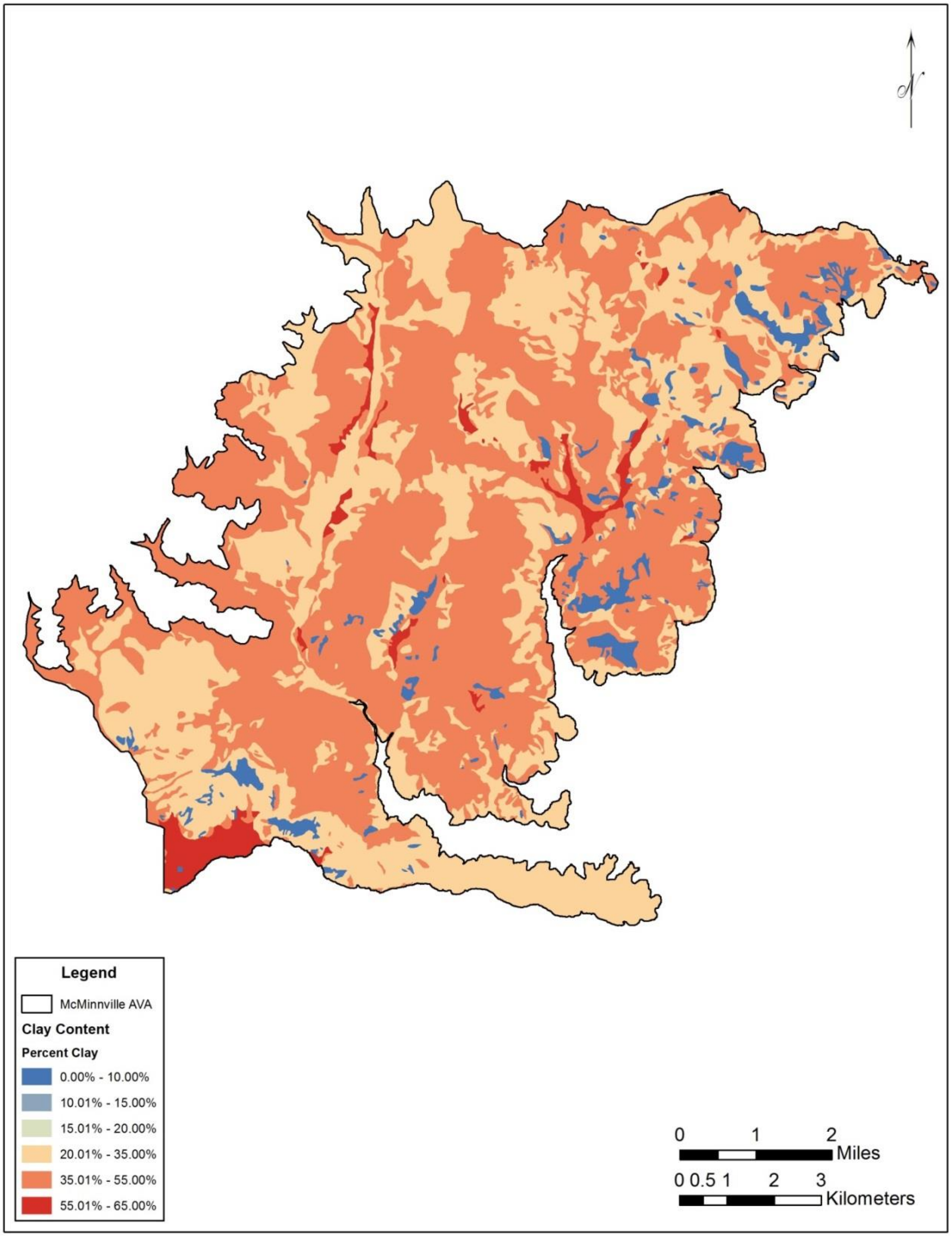

Figure 3.6b – Clay Content of the McMinnville American Viticultural Area

3.7 – Results: Eola-Amity Hills Viticultural Area

The Eola-Amity Hills AVA, totaling 39,369.4 acres, is located approximately 3 miles to the west and northwest of the state Capital of Salem. It is unique among the sub-AVAs of the northern Willamette Valley in that it is not geographically contiguous with any other sub-AVA, and is separated from the McMinnville AVA to the northwest by approximately 4 miles, the Yamhill-Carlton AVA to the north by approximately 6.5 miles, and the Dundee Hills AVA to the north-northeast by approximately 5.5 miles. With regard to soil order (Figure 3.6a), the Chehalem Mountains AVA is not dominated by a single soil order, but is primarily comprised of Mollisols (42.45%) and Ultisols (38.85%), with the remainder comprised of Inceptisols (11.73%) and Alfisols (5.36%).

The Eola-Amity Hills AVA contains significant amounts of Jory, Nekia, Chehulpum-Steiwer, Ritner, and Woodburn soils, but no one soil dominates. The two largest soil series are the Jory series (18.65%) and the Nekia series (18.27%). The remainder is comprised of the Chehulpum-Steiwer complex (11.11%), the Ritner series (9.26%), the Woodburn series (7.81%), and the Yamhill series (7.19%), with the remaining 27% comprised of a mishmash of different soil series including Hazelair, Willakenzie, Helvetia, Witzel, and Helmick, all under 4% respectively. The parent material is a mixture of colluvium and residuum derived from basalt, tuffaceous materials, and basic igneous rock. Approximately 49% of the soil series are mapped as having 40-50% clay content, with approximately 47% of the soils mapped as having 20-40% clay content (Figure 3.6b).

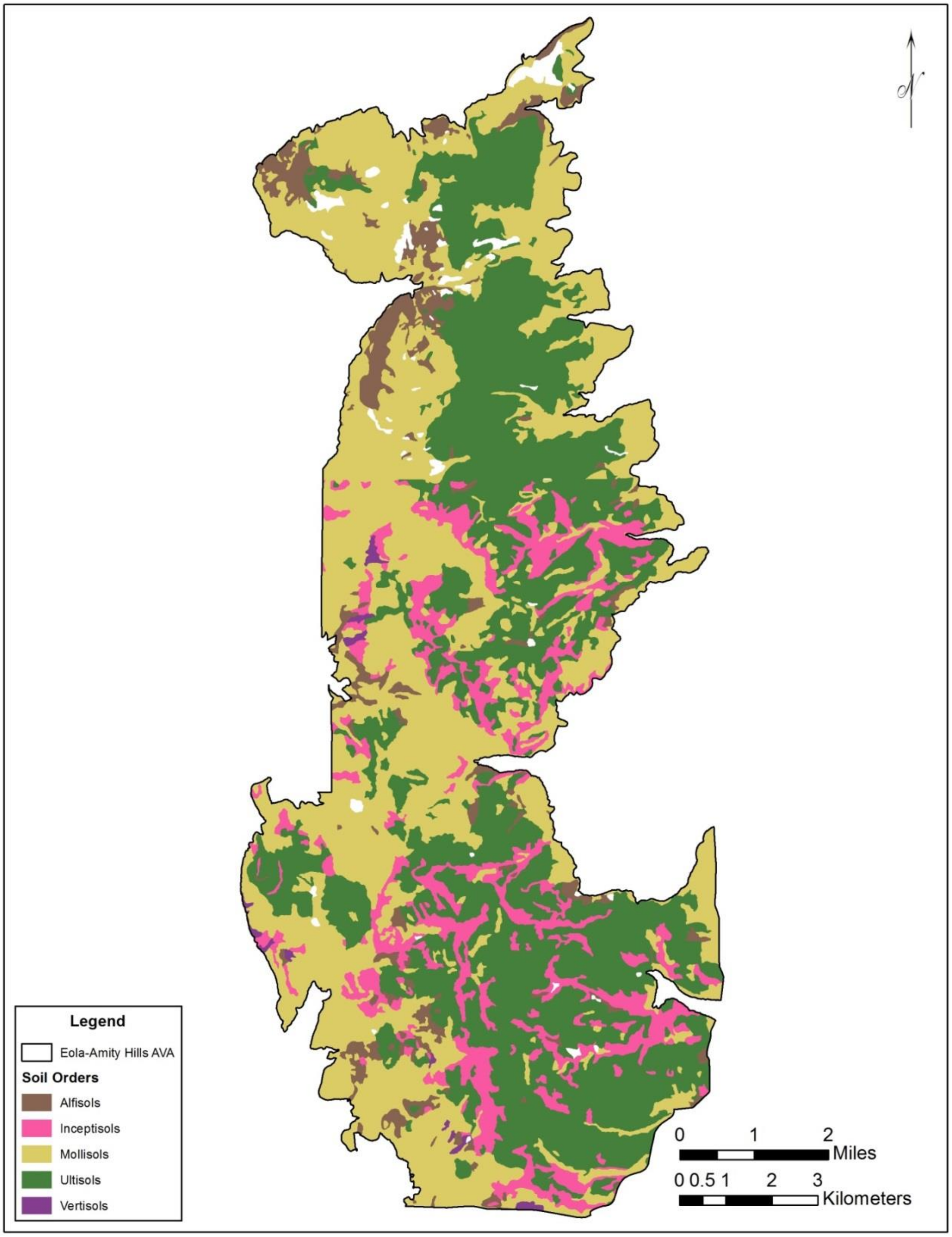

Figure 3.7a – Soil Orders of the Eola-Amity Hills American Viticultural Area

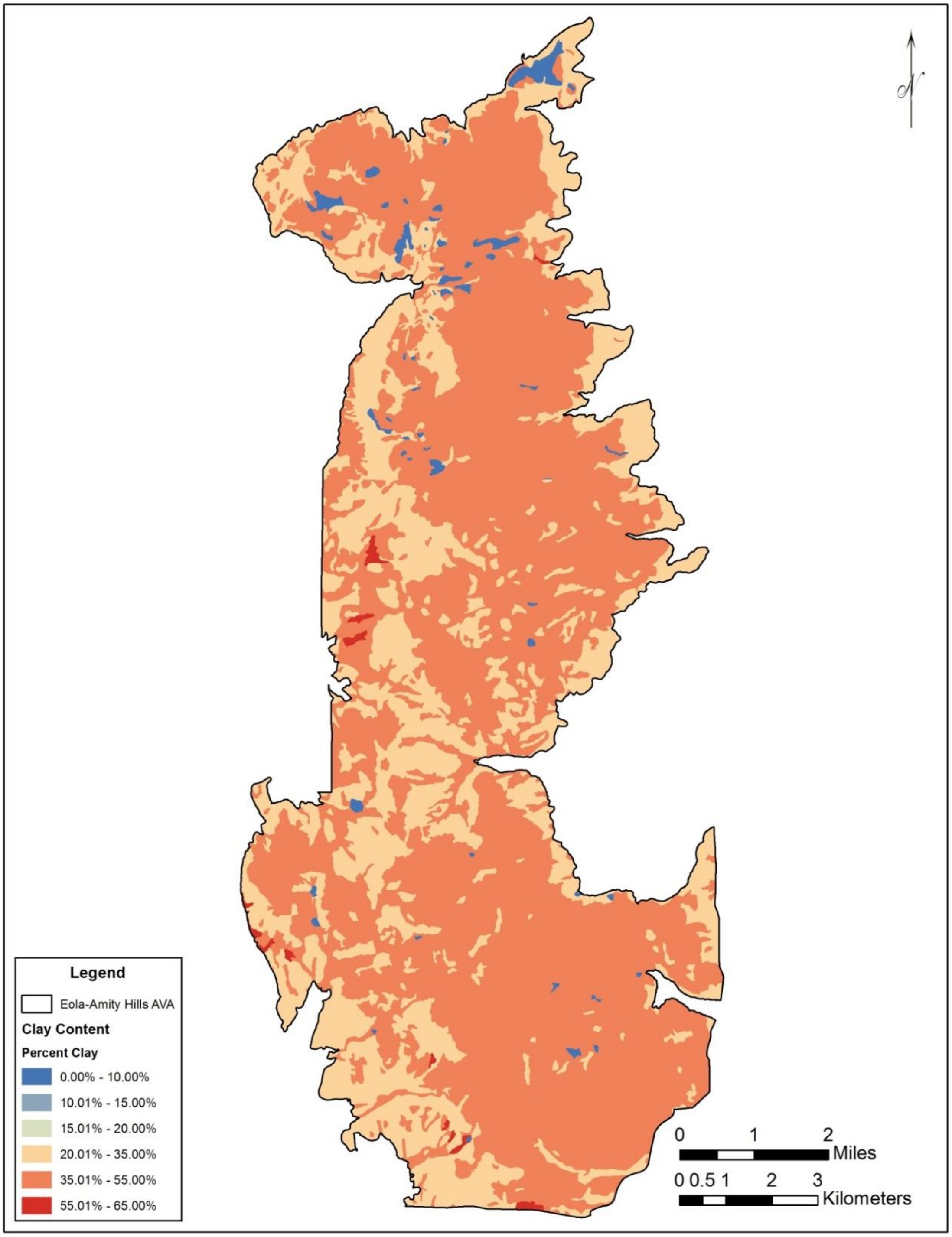

Figure 3.7b – Clay Content of the Eola-Amity Hills American Viticultural Area

3.8 – Results: Willamette Valley AVA Soil Bar Charts

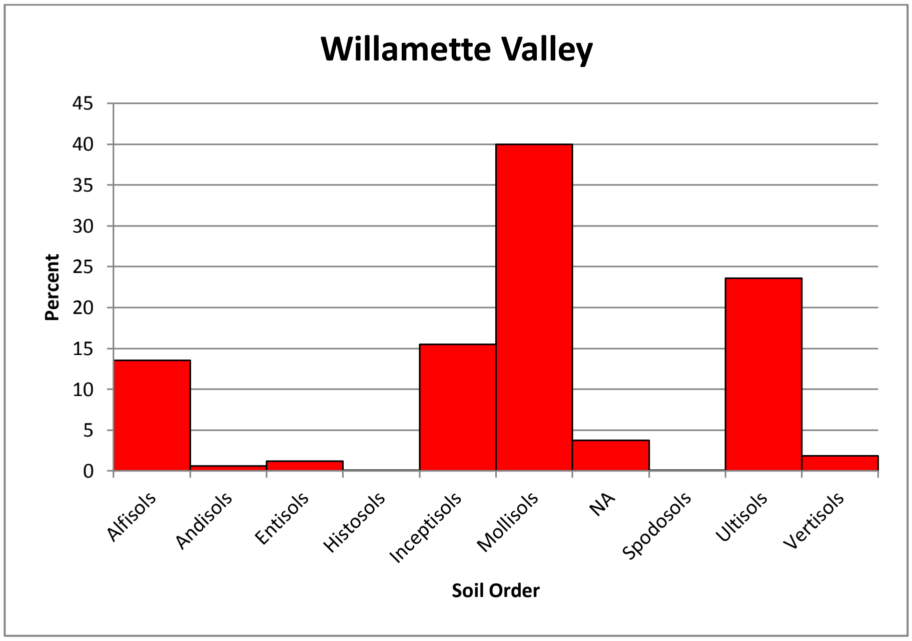

Figure 3.8a – Willamette Valley AVA Soil Order Bar Chart

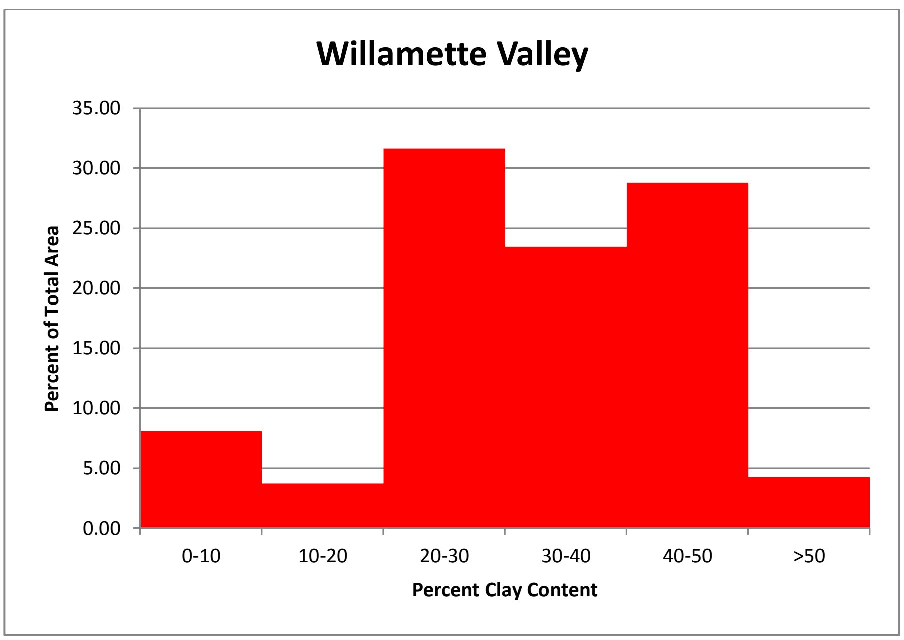

Figure 3.8b – Willamette Valley AVA Percent Clay Content Bar Chart

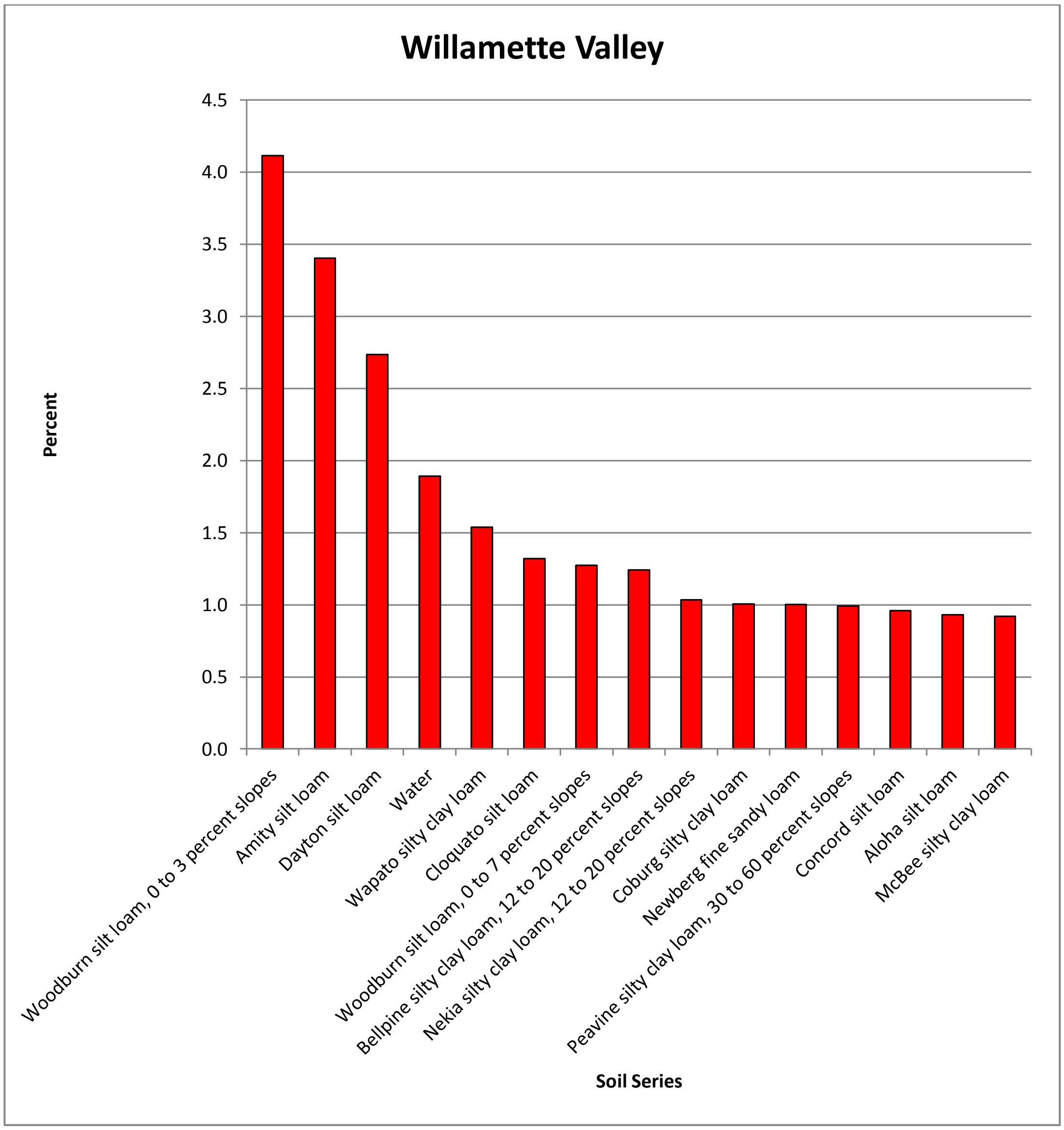

Figure 3.8c – Willamette Valley AVA Top 15 Soil Series Bar Chart

3.9 – Results: Chehalem Mountains AVA Soil Bar Charts

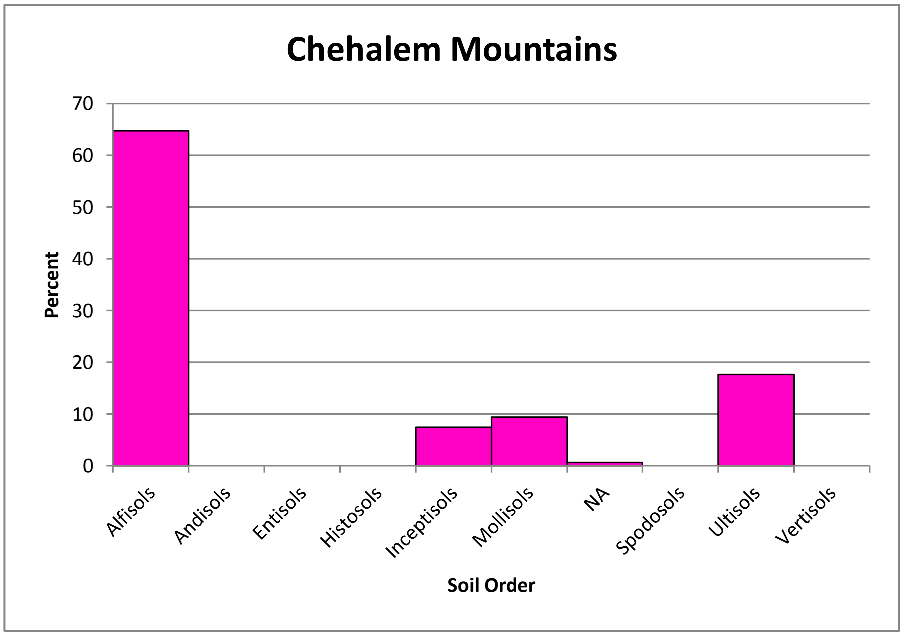

Figure 3.9a – Chehalem Mountains AVA Soil Order Bar Chart

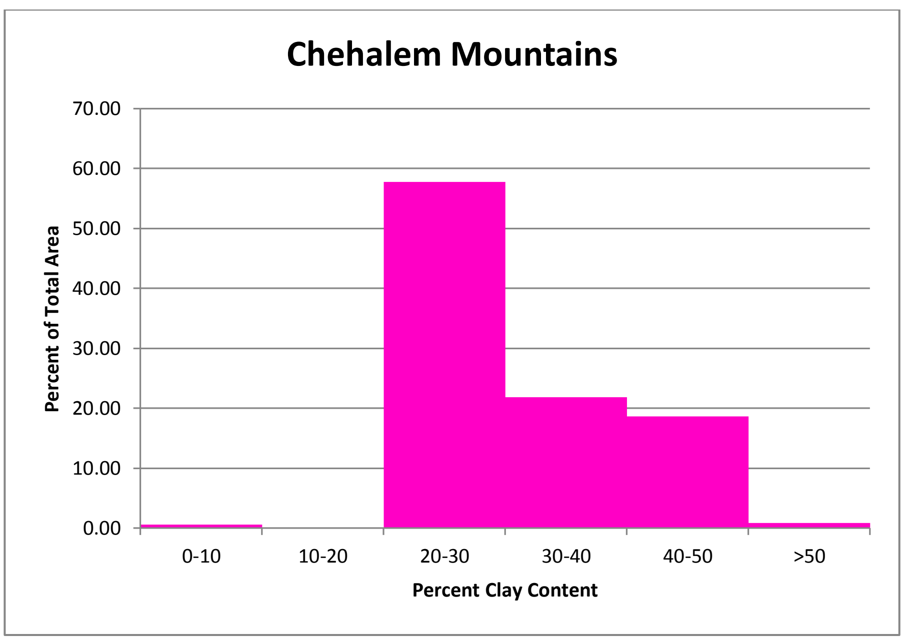

Figure 3.9b – Chehalem Mountains AVA Percent Clay Content Bar Chart

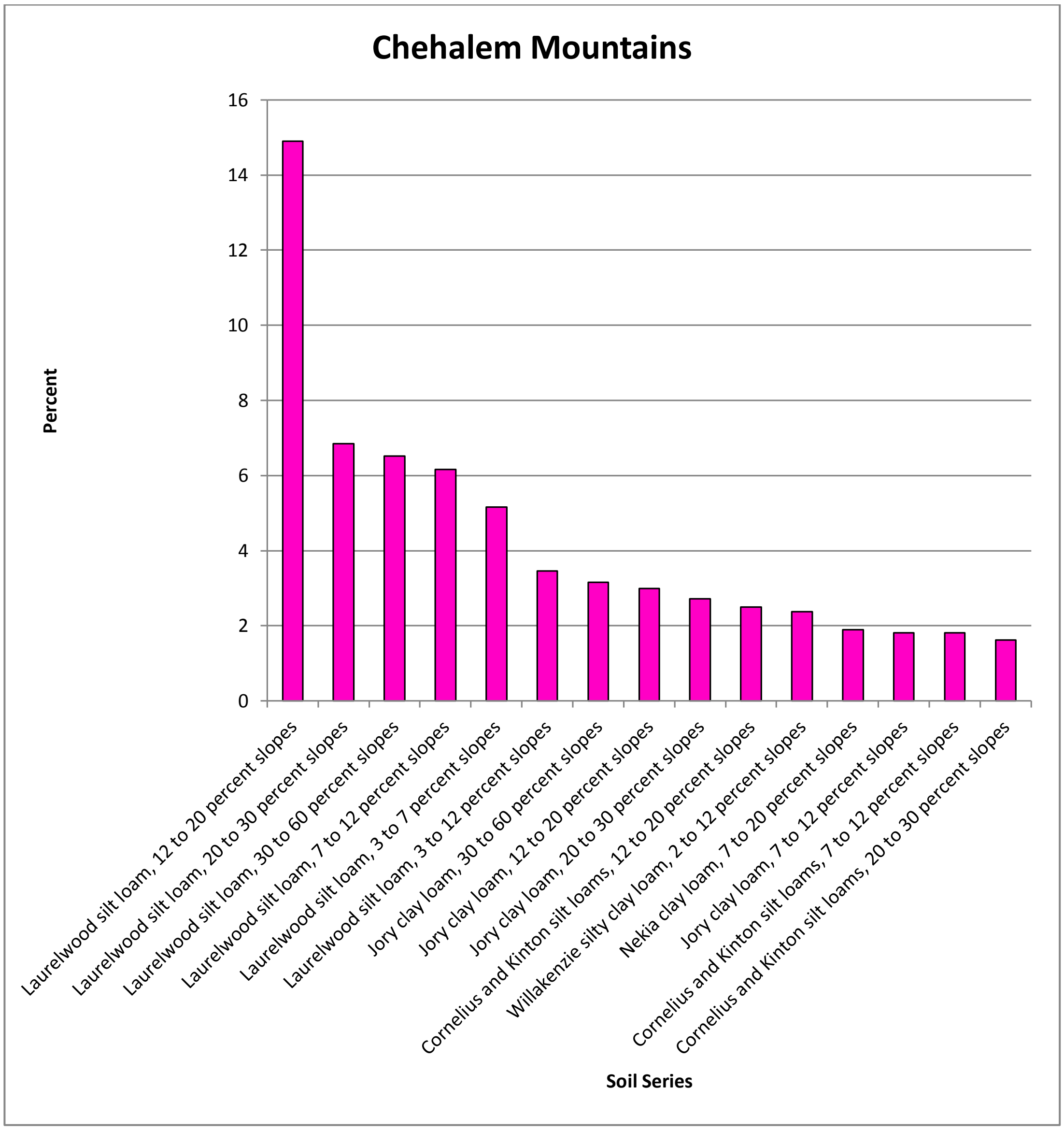

Figure 3.9c – Chehalem Mountains AVA Top 15 Soil Series Bar Chart

3.10 – Results: Ribbon Ridge AVA Soil Bar Charts

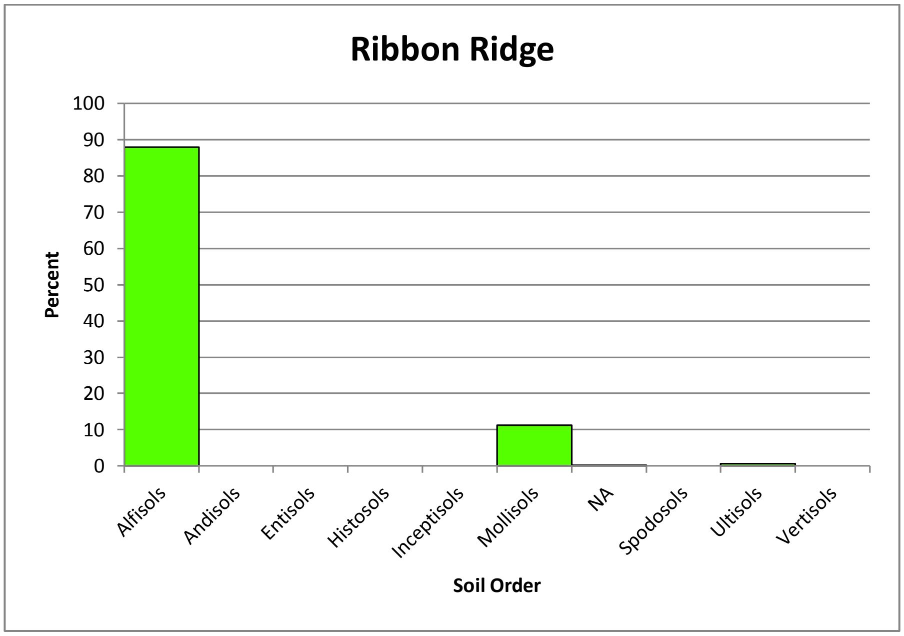

Figure 3.10a – Ribbon Ridge AVA Soil Order Bar Chart

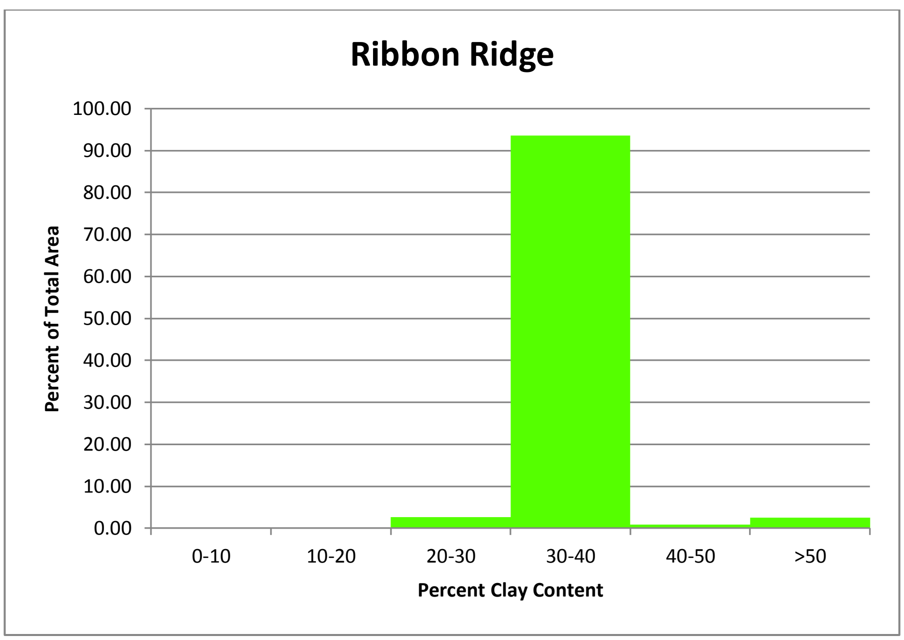

Figure 3.10b – Ribbon Ridge AVA Percent Clay Content Bar Chart

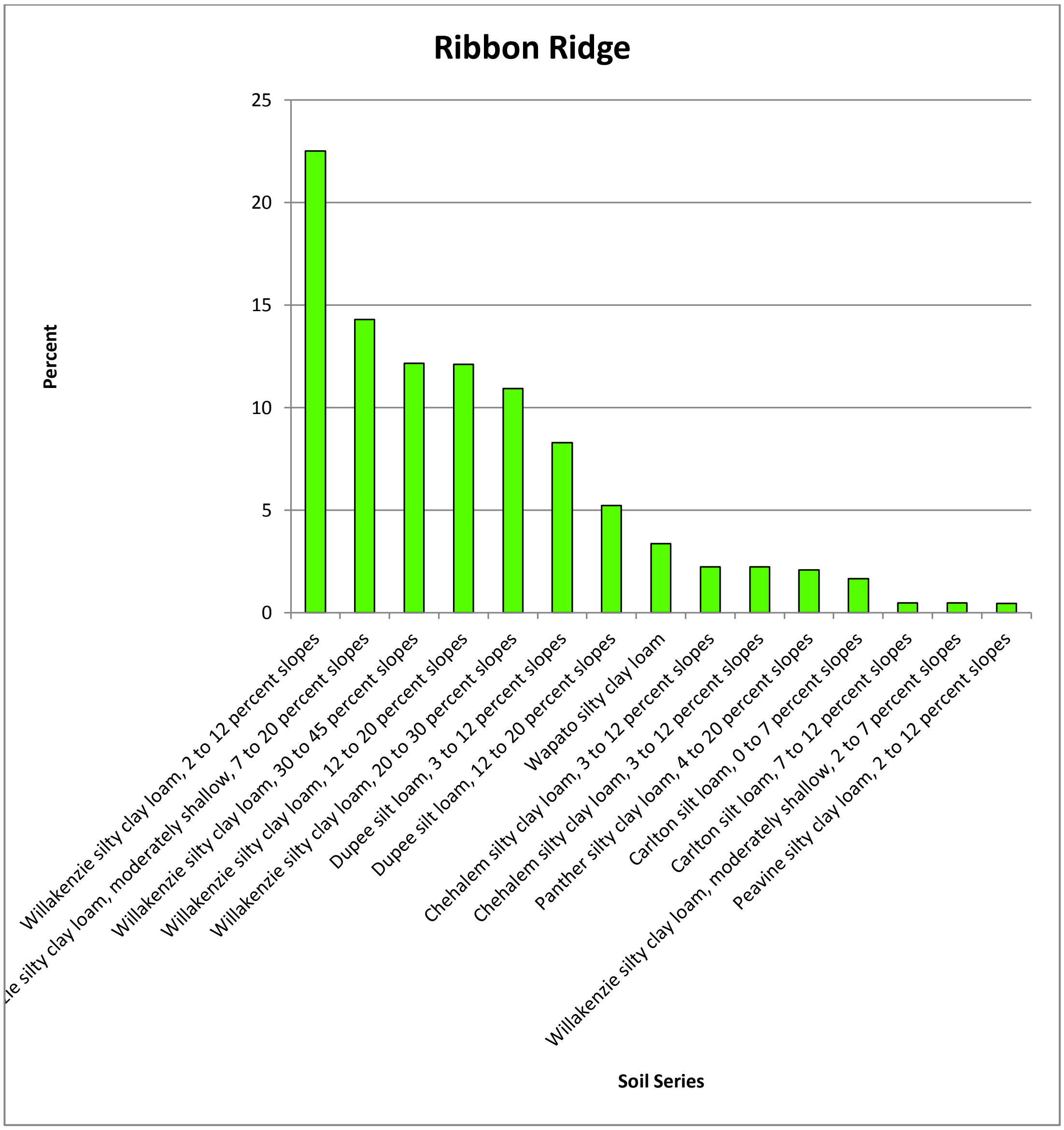

Figure 3.10c – Ribbon Ridge AVA Top 15 Soil Series Bar Chart

3.11 – Results: Dundee Hills AVA Soil Bar Charts

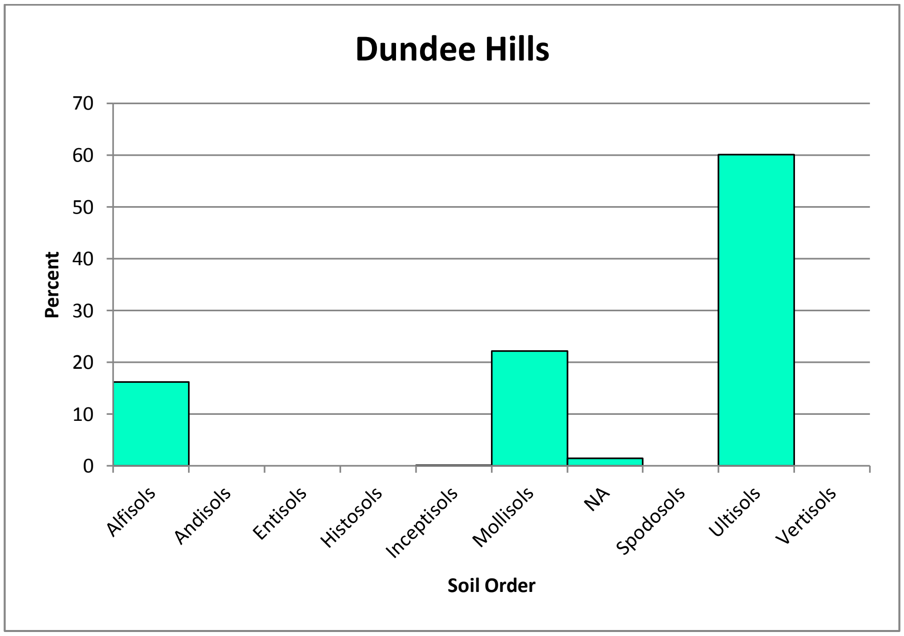

Figure 3.11a – Dundee Hills AVA Soil Order Bar Chart

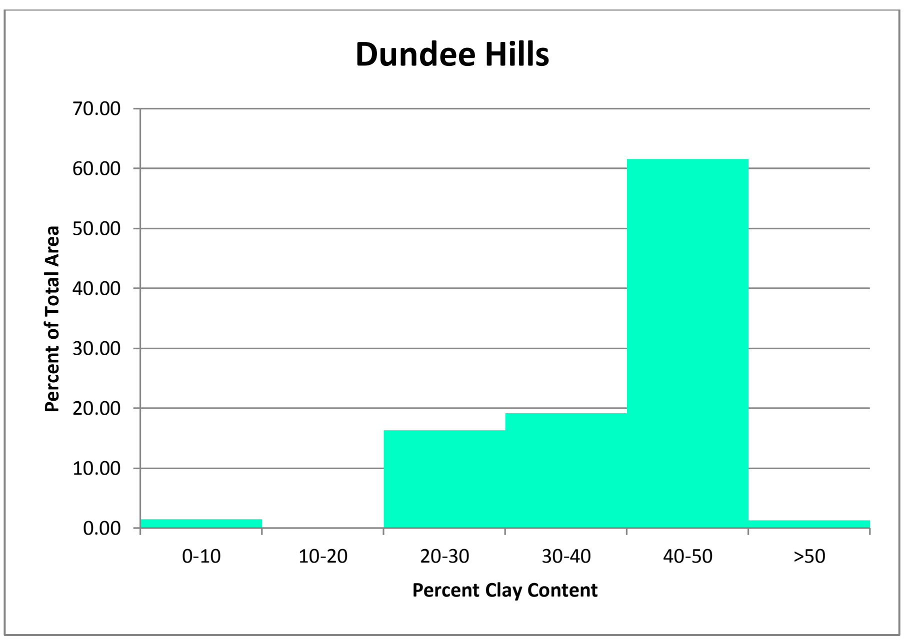

Figure 3.11b – Dundee Hills AVA Percent Clay Content Bar Chart

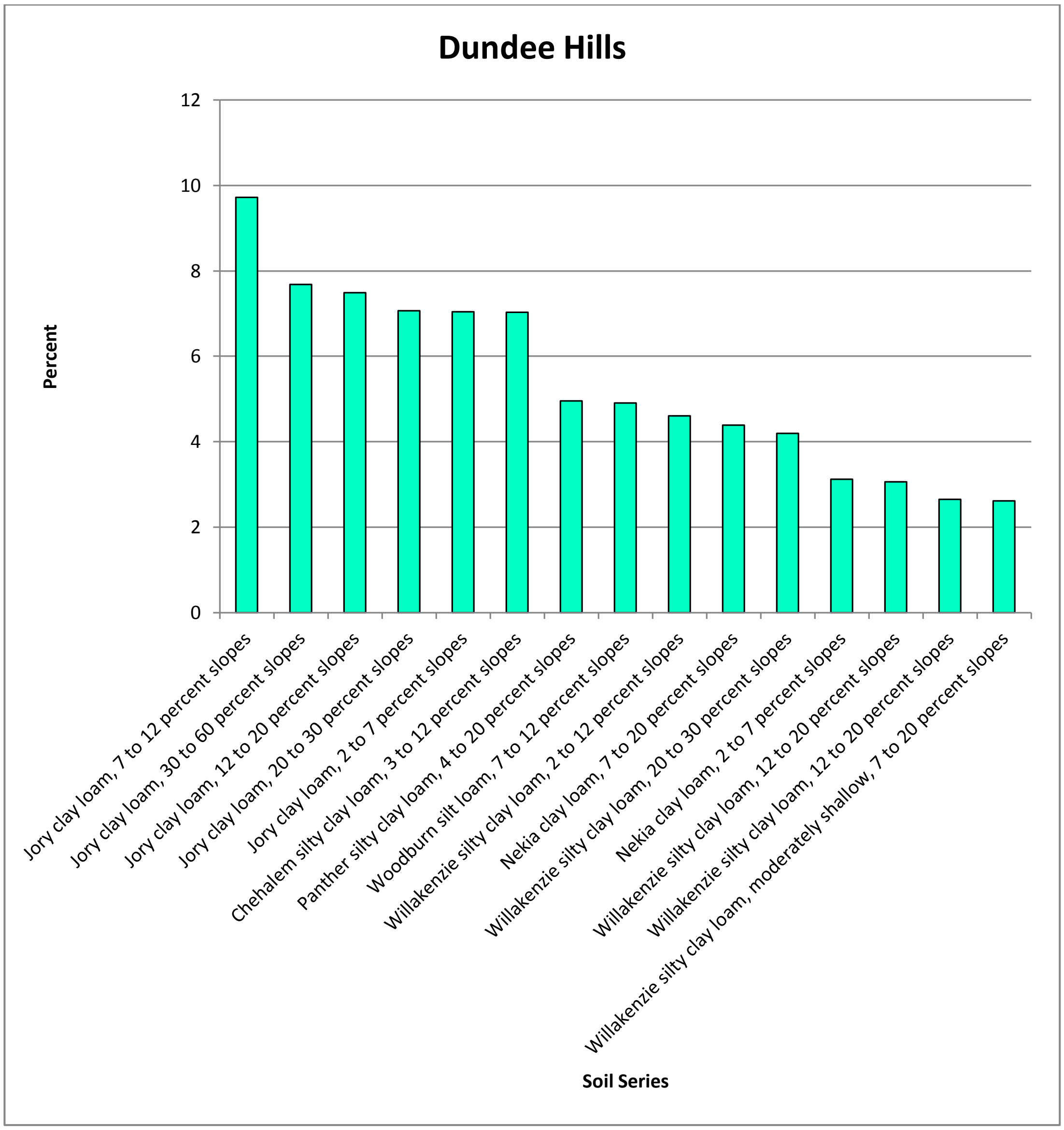

Figure 3.11c – Dundee Hills AVA Top 15 Soil Series Bar Chart

3.12 – Results: Yamhill-Carlton AVA Soil Bar Charts

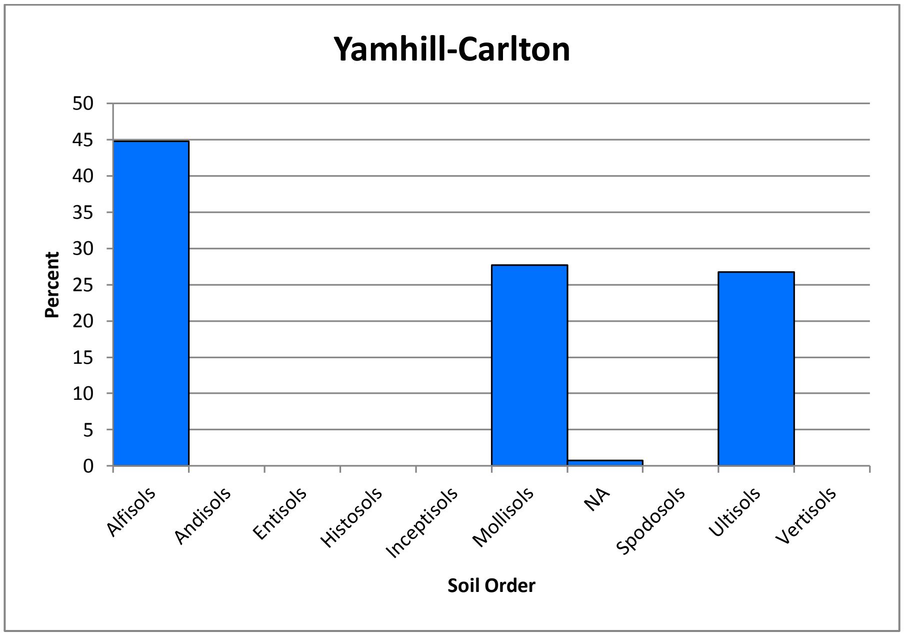

Figure 3.12a – Yamhill-Carlton AVA Soil Order Bar Chart

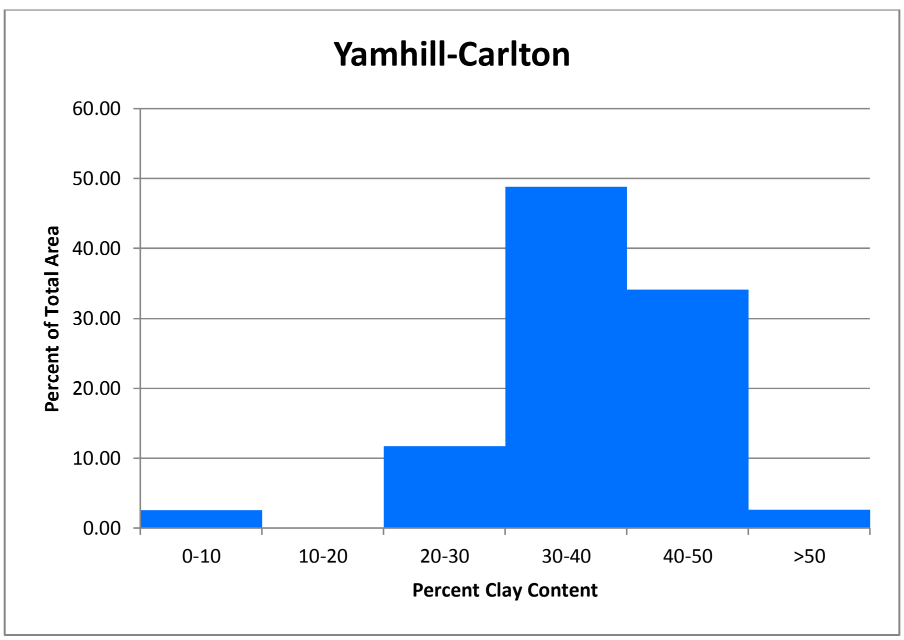

Figure 3.12b – Yamhill-Carlton AVA Percent Clay Content Bar Chart

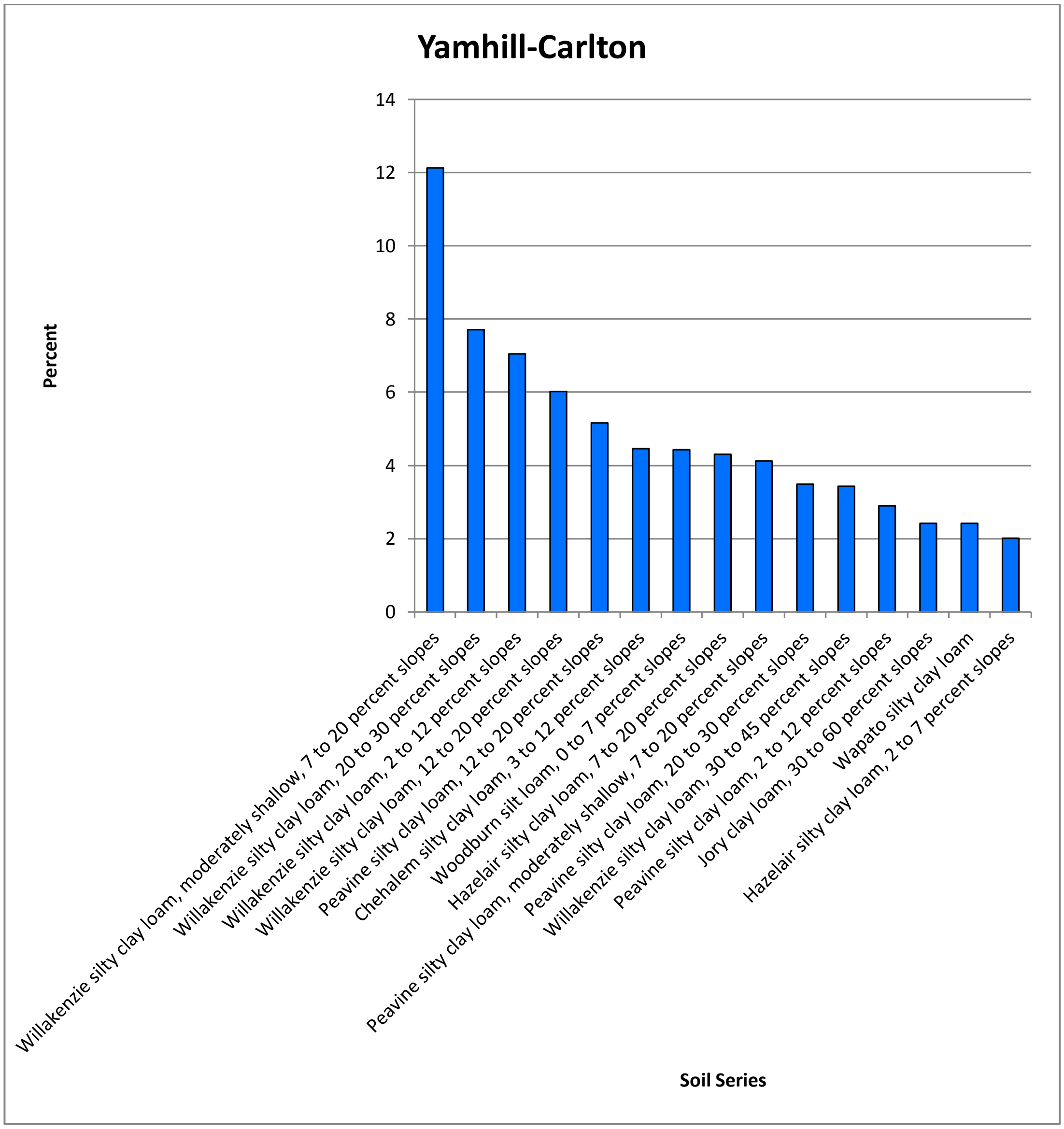

Figure 3.12c – Yamhill-Carlton AVA Top 15 Soil Series Bar Chart

3.13 – Results: McMinnville AVA Soil Bar Charts

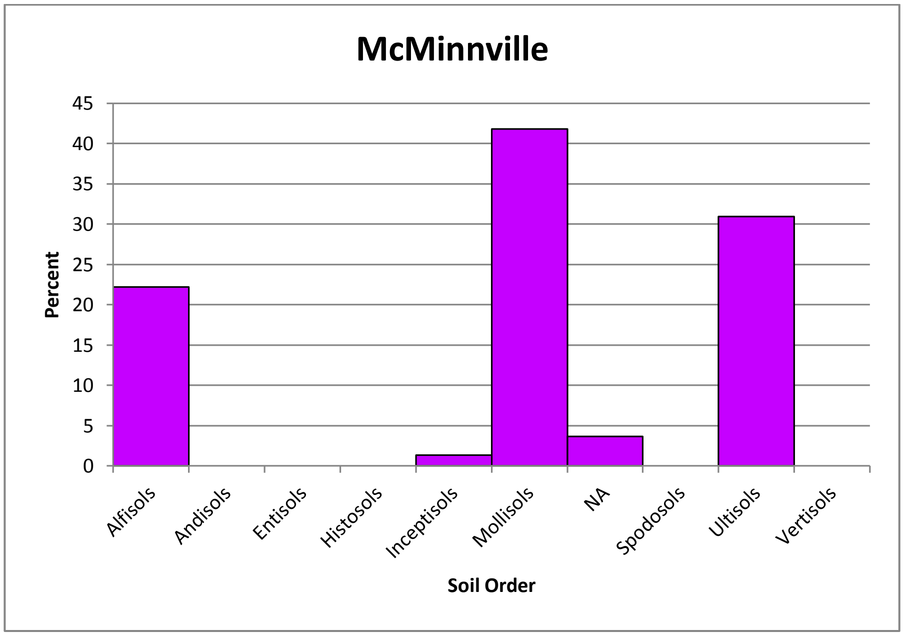

Figure 3.13a – McMinnville AVA Soil Order Bar Chart

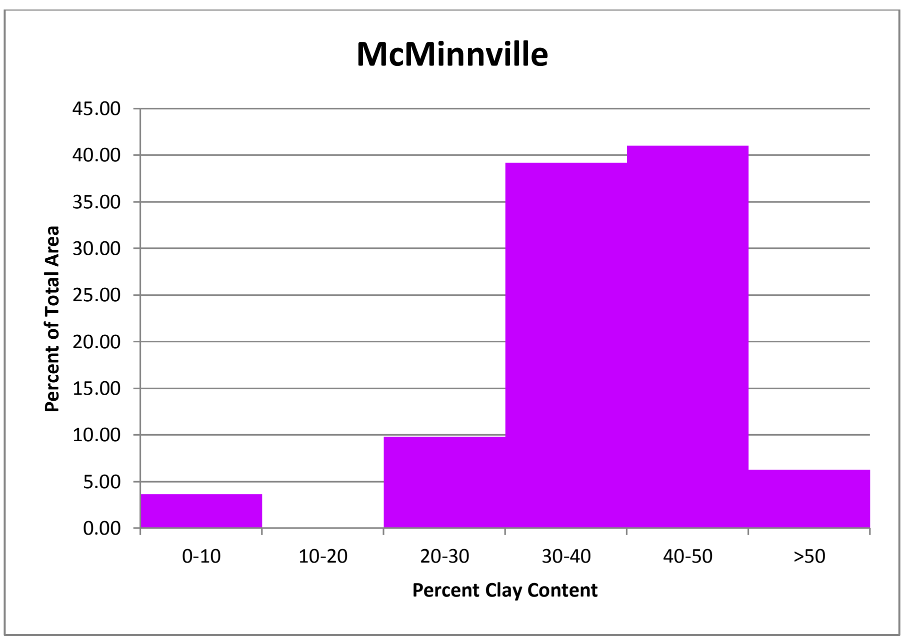

Figure 3.13b – McMinnville AVA Percent Clay Content Bar Chart

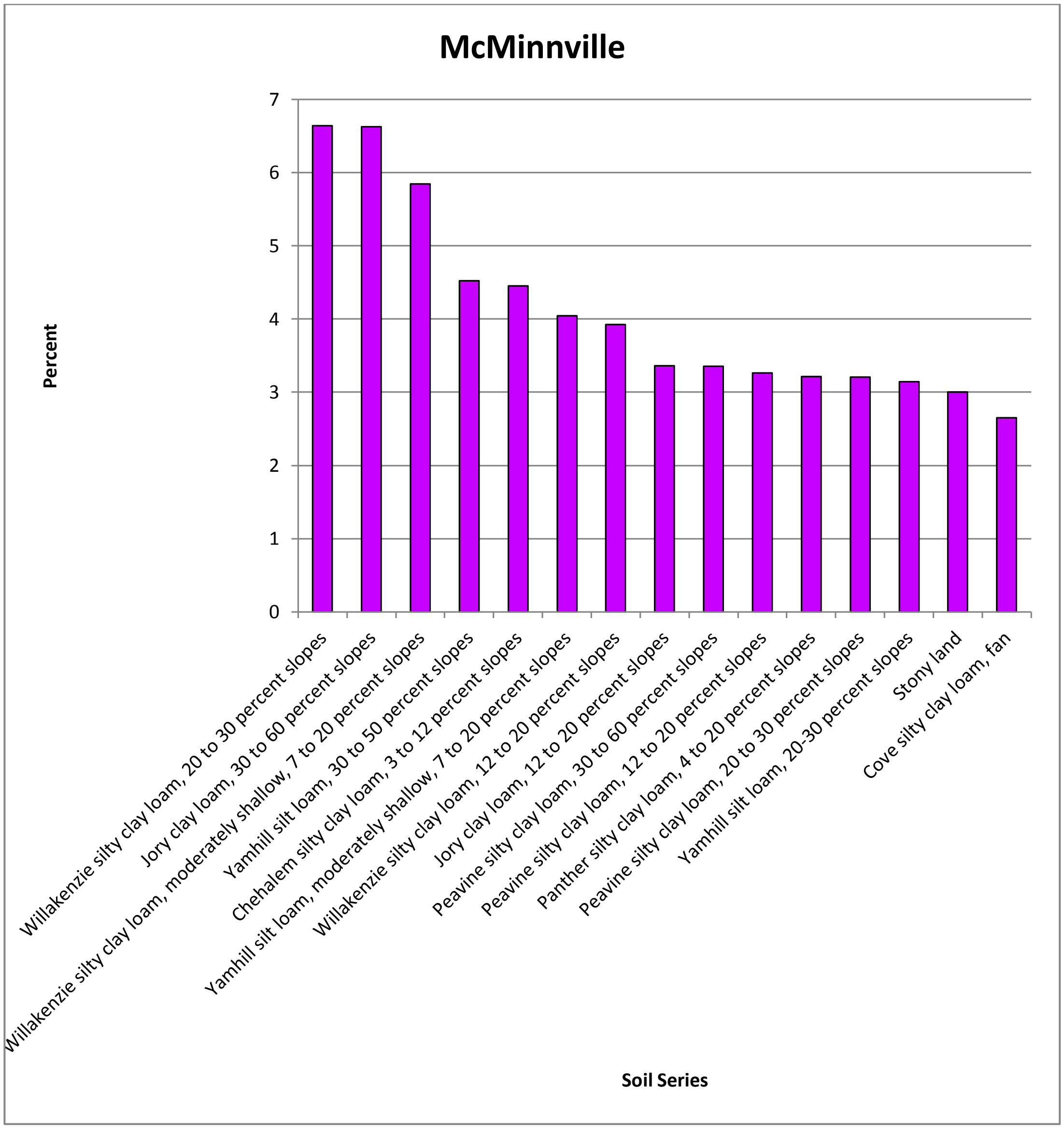

Figure 3.13c – McMinnville AVA Top 15 Soil Series Bar Chart

3.14 – Results: Eola-Amity Hills AVA Soil Bar Charts

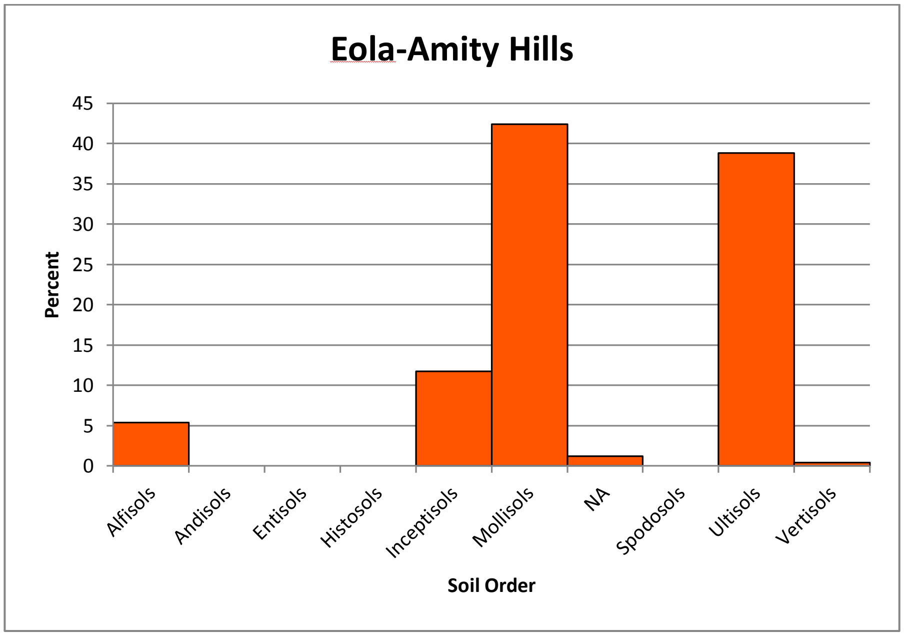

Figure 3.14a – Eola-Amity Hills AVA Soil Order Bar Chart

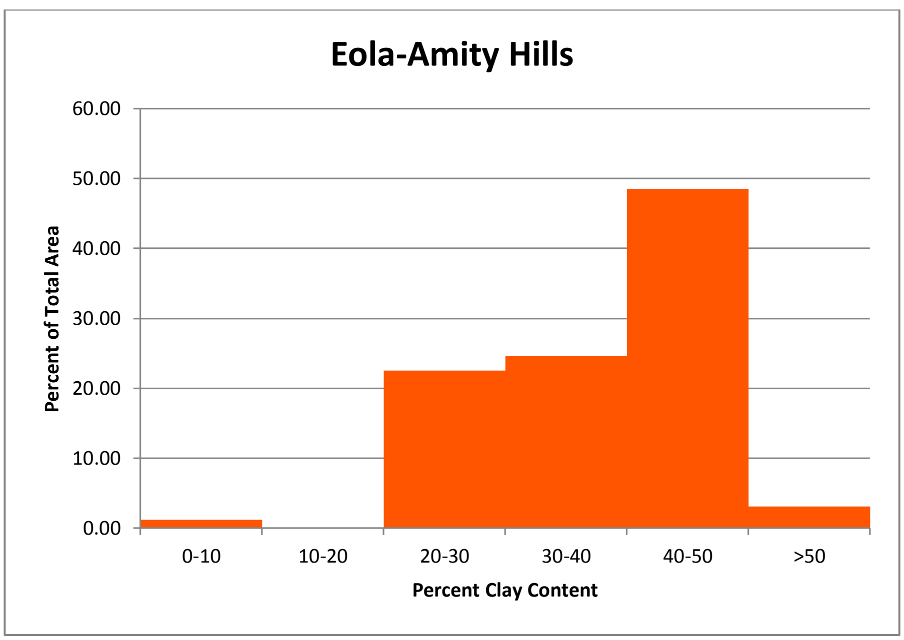

Figure 3.14b – Eola-Amity Hills AVA Percent Clay Content Bar Chart

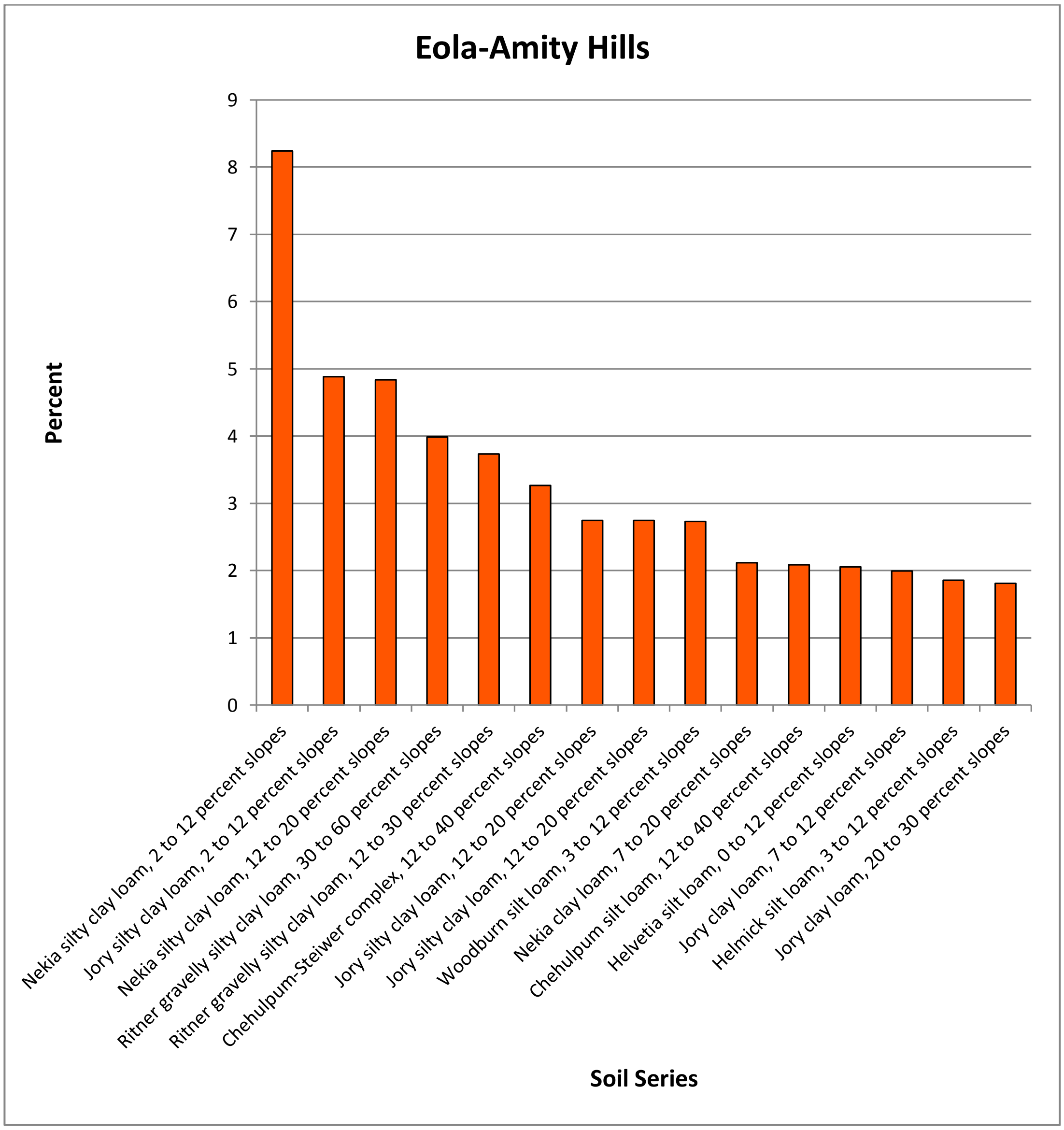

Figure 3.14c – Eola-Amity Hills AVA Top 15 Soil Series Bar Chart

Chapter 4 – Discussion

4.1 – Overview

As is clearly evident when evaluating the size and scope of the entire Willamette Valley AVA, the region is incredibly heterogeneous. Given the size of the AVA, and the degree of soil diversity within the Willamette Valley, this heterogeneity is unsurprising. While this AVA designation serves as a broad Geographic Indicator, it does not offer the specificity associated with the narrower scope of the French AOC system, nor does it lend itself well to the concept of *terroir*. A convincing argument can be made that the smaller sub-AVAs in the northern Willamette Valley provide a more nuanced sense of place with regard to wine geography.

While in some cases, delineating the geography of a winegrowing region is best done by small size alone, in other cases, delineating the geography of a winegrowing region based on soil homogeneity at a coarser scale can provide this as well. Of the seven AVAs analyzed in this study, the six sub-AVAs of Chehalem Mountains, Ribbon Ridge, Dundee Hills, Yamhill-Carlton, McMinnville, and Eola-Amity Hills all have the distinction of being located in elevated landscapes, above the floor of the Willamette Valley, and as such, less dominated by the Mollisols associated with the Missoula Floods. Many of these sub-AVAs are indeed remnants of prior geopedological development in the Willamette Valley, and are dominated by parent material combinations of colluvium derived from sedimentary rock and basalt. The soil series in these sub-AVAs also generally contain higher percentages of clay content than the surrounding areas and the greater Willamette Valley (Figure 3.1b).

4.2 – Differing Characteristics of the northern Willamette Valley sub-AVAs

There are however, exceptions to this. In the case of Chehalem Mountains, there is a clear divide between the northeastern slope and the southwestern slope of the defining ridge in that landscape, with the northeastern slope's parent material dominated by wind-blown loess, and the southwestern slope's parent material dominated by colluvium derived from basalt and sedimentary rock. This stark division in parent material is also reflected in differences of soil orders, soil series, and clay content, all of which are readily apparent when viewing maps of the area (Figures 3.2a and 3.2b).

The smaller Ribbon Ridge AVA, which has the unique distinction of being both a sub-AVA of the Willamette Valley AVA as well as the Chehalem Mountains AVA, is undoubtedly the most homogeneous of the AVAs in the Willamette Valley with regard to soil order, soil series, parent material, and percent clay content. At 3,489.53 acres, Alfisols make up almost 90% of the AVA's area. This AVA is comprised of mostly of the Willakenzie soil series, which make up over 75% of the total area of the AVA. While its overall clay content is lower than most of the other sub-AVAs in the northern Willamette Valley, its homogeneity in soil order, soil series, and parent material make it arguably the best representation of *terroir* in the region.

The Dundee Hills AVA, just to the south of Ribbon Ridge AVA, is also relatively small compared to the other sub-AVAs, and has a total of 12,424.3 acres. It is the second smallest sub-AVA in the region, and while directly south of Ribbon Ridge AVA, is quite different. It is located approximately halfway between the two main towns in Oregon's Pinot noir wine country, Newberg and McMinnville. Dundee Hills is the only sub-AVA in the northern Willamette Valley that is dominated by Ultisols, which comprise just over 60% of the AVA's total area (Figure 3.3a). This strong concentration of Ultisols directly corresponds to medium to high percentages of clay content (Figure 3.3b). In contrast to the Ribbon Ridge AVA, more than half of the soils are of the Jory soil series, at 58.34%. Perhaps because of its small size, but also because of its relative soil homogeneity, the Dundee Hills AVA is a better representation of the region's soil than most of the other sub-AVAs in the northern Willamette Valley.

The Yamhill-Carlton AVA, just to the west of both the Ribbon Ridge and Dundee Hills AVAs, is more diverse in soil order than either the Ribbon

Ridge AVA or the Dundee Hills AVA. The second largest sub-AVA in the northern Willamette Valley, at 56,759.5 acres, it has a rather unusual shape when compared to the other sub-AVAs in the area. The Yamhill-Carlton AVA is nestled in the upper elevations of the low-lying valley of the North Yamhill River, and is centered around the towns of Yamhill and Carlton, immediately north of McMinnville. Appearing on the map like an upside-down horseshoe, it is dominated by Alfisols (44.79%) in the eastern half. The Ultisols of the AVA, while only comprising 26.76%, are more concentrated in the western half of the AVA. The difference is made up of Mollisols, which are scattered throughout, but more generally are concentrated in the lower elevations and valley floors of the AVA (Figure 3.4a). Similar to the soil order composition of the AVA, no one soil series dominates the total area. The largest soil series is the Willakenzie, which only comprises 38.46%, followed by the Peavine at 19.75%, and the Woodburn series at 18.71%. The remaining 23% of the AVA's total area is primarily made up of the Jory, Wapato, Hazelair, and Chehalem soil series, each of which comprise no more than 10% of the total area of the Yamhill-Carlton AVA. Predictably, high clay concentrations correlate quite well with the Ultisols in the western half of the AVA (Figure 3.4b).

The McMinnville AVA, just to the southwest of the Yamhill-Carlton AVA, has a total of 36,432.5 acres, and shares a small border with the Yamhill-Carlton AVA. It is immediately to the west of the city of McMinnville, and extends southwest toward the town of Sheridan. Most of the AVA is between the elevations of 200 and 800 feet. Similar to the Yamhill-Carlton AVA, no one soil order is dominant. Whereas Alfisols is the largest soil order in Yamhill-Carlton, it only comprises 22.23% of the McMinnville AVA. The largest soil order in the AVA is Mollisols, at 41.83%, which is concentrated in lower elevations and valley floors of the AVA. Ultisols, at 30.98%, are concentrated in the higher elevations of the AVA along with the aforementioned Alfisols (Figure 3.5a). The smallest soil order present within the AVA is Inceptisols, which only comprise 1.32% of the total area, and are concentrated in the north central portion of the AVA. While similar to the Yamhill-Carlton AVA in that it is not dominated by a single soil order, the McMinnville AVA is much more diverse and heterogeneous than the Yamhill-Carlton AVA with regard to soil series. The McMinnville AVA is the only sub-AVA in the northern Willamette Valley for which no soil series comprises more than a quarter of the total area. The largest soil series in the AVA is Willakenzie, at 21.65%. The next four largest soil series are the Jory series at 14.5%, the Yamhill series at 14.21%, the Peavine series at 13.36%, and the Steiwer series at 5.42%. The remaining 30% of the total area of the AVA is comprised of a mixture of eight main soil series (Chehalem, Cove, Panther, Carlton, Olyic, Hazelair, Amity, and Willamette), none of which totals more than 5% of the total area of the AVA. Correlating with the distribution of soil orders within the AVA, clay content is equally diffused (Figure 3.5b). The McMinnville AVA is by far the least homogeneous of the northern Willamette Valley sub-AVAs, and does not lend itself well to the concept of *terroir*.

At first glance, the Eola-Amity Hills AVA is the most distinct of the six northern Willamette Valley sub-AVAs, primarily because it is not geographically contiguous with any of the other sub-AVAs. It is directly west and northwest of Salem, and runs approximately 20 miles north towards McMinnville, but is separated from the McMinnville AVA by 4 miles and the Dundee Hills AVA by 5.5 miles. Slightly larger than the McMinnville AVA, it totals 39,369.4 acres, and encompasses the Amity Hills in the northern portion of the AVA and the Eola Hills in the southern portion of the AVA. Similar to the McMinnville AVA, the Eola-Amity Hills AVA is not dominated by a single soil order, but instead by two soil orders instead. Mollisols comprise 42.45%, closely followed by Ultisols at 38.85%, with the remainder comprised of Inceptisols and Alfisols, at 11.73% and 5.36%, respectively (Figure 3.6a). The two largest soil series are the Jory series at 18.65% and the Nekia series at 18.27%. The remainder is comprised of the Chehulpum-Steiwer complex (11.11%), the Ritner series (9.26%), the Woodburn series (7.81%), and the Yamhill series (7.19%). The remaining 27% of the soils are comprised primarily of the Hazelair, Willakenzie, Helvetia, Witzel, and Helmick, all of which are under 4%. In contrast to the spatially diffused clay concentrations in the

McMinnville AVA, the clay concentrations in the Eola-Amity Hills AVA are well distributed throughout the total area of the AVA (Figure 3.6b).

4.3 – Discussion Summary

As is evidenced by the data produced in this study, a number of the sub-AVAs in Oregon's northern Willamette Valley do indeed correspond well to underlying soil characteristics such as soil order, soil series, percent clay content, and parent material. Perhaps the two best examples of this type of acute correspondence are the Ribbon Ridge AVA and the Dundee Hills AVA. Using the four previously mentioned metrics, both of these sub-AVAs correspond quite well to the soil characteristics within their boundaries. Perhaps the least best example of this correspondence is the McMinnville AVA, in which there is neither a clearly dominant soil order or soil series present. In the cases of the Yamhill-Carlton AVA, the Chehalem Mountains AVA, and the Eola-Amity Hills AVA, some of the measured metrics are dominant, yet others are not. Using a more robust analysis might help provide further insight into the extent to which these individual sub-AVAs correspond to the soil characteristics within their boundaries.

Chapter 5 – Conclusion

5.1 – Overview

In conclusion, while there are circumstances in which American Viticultural Areas accurately represent and correspond to soil classes in the northern Willamette Valley, there are other circumstances in which AVAs do not accurately represent and correspond to soil classes. For example, as previously discussed, the Ribbon Ridge AVA more accurately represents and corresponds to the soil classes within its boundary than does the larger Chehalem Mountains AVA. In comparing these two particular AVAs, an argument could be made that the accuracy of the Ribbon Ridge AVA is specifically because of its small size, and that the lack of accuracy between the Chehalem Mountains AVA and its corresponding soils classes is because of its large size. However, there are other, relatively large sub-AVAs (e.g. Yamhill-Carlton AVA) that accurately represent and correspond to soil classes within their boundaries. At question here, then, is not necessarily the size of the AVA, but the petitioning and decision making processes that lead to their designation by the TTB as AVAs.

5.2 – Summary

As a result of the discrepancies between the accuracy of different AVAs, and the relative lack of geographic research being conducted in this area, a strong case can be made that more research is required to: (1) sufficiently address these discrepancies, (2) determine whether AVA classification is, in and of itself, a useful designator of uniqueness with regard to winegrape production, and (3) develop more robust, scalable, and repeatable objective analytical means to employ in both the petitioning for and designation of American Viticultural Areas.

With regard to addressing discrepancies in the correlation of AVA boundaries and soil classes, it is imperative that further research incorporates empirical geospatial analysis. Outlying issues include the size and scope of AVAs, and the inherent variability between and within different AVAs throughout the United States, and analytical means with which wine geographers can effectively compare and contrast competing AVAs, particularly ones that share similarities in landscape, climate, soil, and a reputation for a specific winegrape or winegrapes' production.

Utilizing AVA classification as a primary designator of uniqueness requires that AVA designation and related research incorporate objective, empirical evidence measuring variables such as climate, soils, elevation, and geology. As it stands now, petitioning for AVA designation does not require any direct sampling of soil samples, atmospheric data, or for that matter, wine made from grapes grown in the region in question. A compelling argument can be made that the increased use of and reliance upon empirical data will improve the designation process because in its absence, a petition relies on qualified, but not quantifiable data.

5.3 – Conclusion

Finally, the techniques and analytical methods used in petitioning and designating American Viticultural Areas require more codification themselves. The system currently in place for approving an American Viticultural Area runs the risk of appearing like a black box, into which resources can be applied, a convincing narrative argued, and approved or denied depending on the whims of the petition reviewers. Both the wine industry and the wine-consuming public would be better served through the implementation of a more robust, transparent system, allowing for scalable, and repeatable results. Given the increased interest in and worldwide consumption of wines produced in the United States, promoting a more defined AVA system increases the knowledge and accessibility of American winegrowing regions. This can be seen in the increased notoriety of the Napa Valley AVA in the last twenty years, and the resulting increases in both production and consumption of wines from this area. More recently, this is evidenced by the increased demand and recognition of premium Pinot noir from the Willamette Valley.

However, although the average wine drinking consumer may recognize the outstanding reputation of Willamette Valley wines, he/she would most likely find it difficult, if not impossible to differentiate between the sub-AVAs of this region and may have a limited understanding of the bureaucratic nuances of the AVA petitioning and designation process. Making this process more transparent and objective would allow for greater recognition of regional uniqueness by the wine-consuming public.

In order to promote a more transparent AVA system, a given region's potential for designation should be independently verifiable. Multiple petitioners, using the same data sets, should produce comparable results. Additional methods of designation could include an objective approval panel, made up of leading scientists with research experience in viticulture and enology, atmospheric science, soil science, geology, and geography. Incorporating the expertise and analytical experience of scientists could potentially dispel any confusion regarding the decisions that approve or deny AVA petitions.

It would benefit leaders in winegrowing regions to call for more stringent methodologies for approving AVA and sub-AVA petitions. Through greater accuracy in the designation of AVAs, civic planning and decision-making in winegrowing regions could become more objective. Further, a more robust AVA-designation process would allow winegrowing regions to differentiate themselves as unique contributors to the U.S wine market.

In conclusion, a more transparent and objective AVA designation process would not only benefit the wine consuming public, but would support the U.S. wine industry as a whole. AVA designation must be indicative of verifiable differences in either soil characteristics or climatic factors. In the absence of this type of differentiation, designation of AVAs and sub-AVAs runs the risk of becoming arbitrary and meaningless, and may, in time, negatively impact the worldwide recognition and value of U.S. wines.

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Appendix

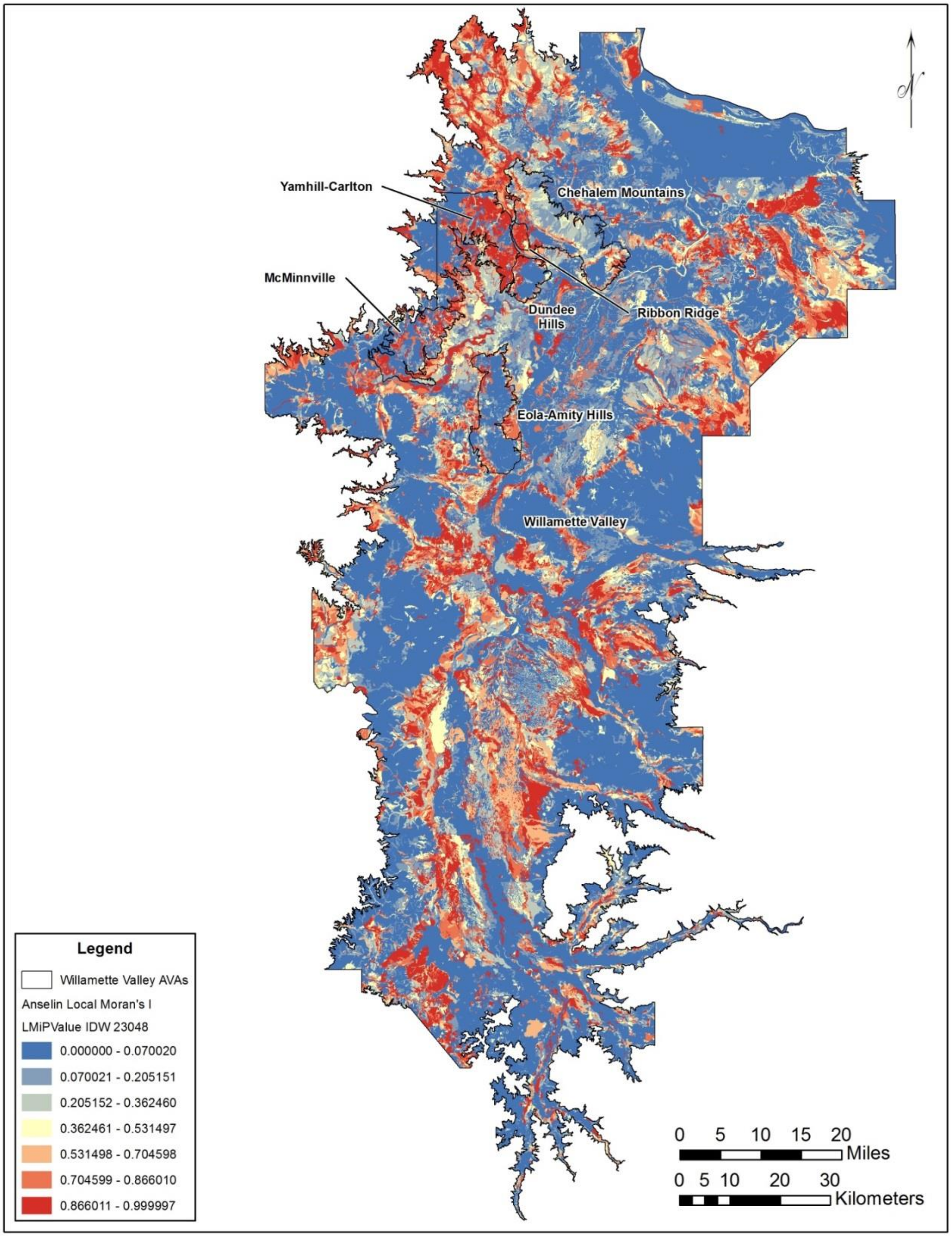

Figure A.1a – Anselin Local Moran's I: P-Value of Clay Content in Willamette Valley AVA

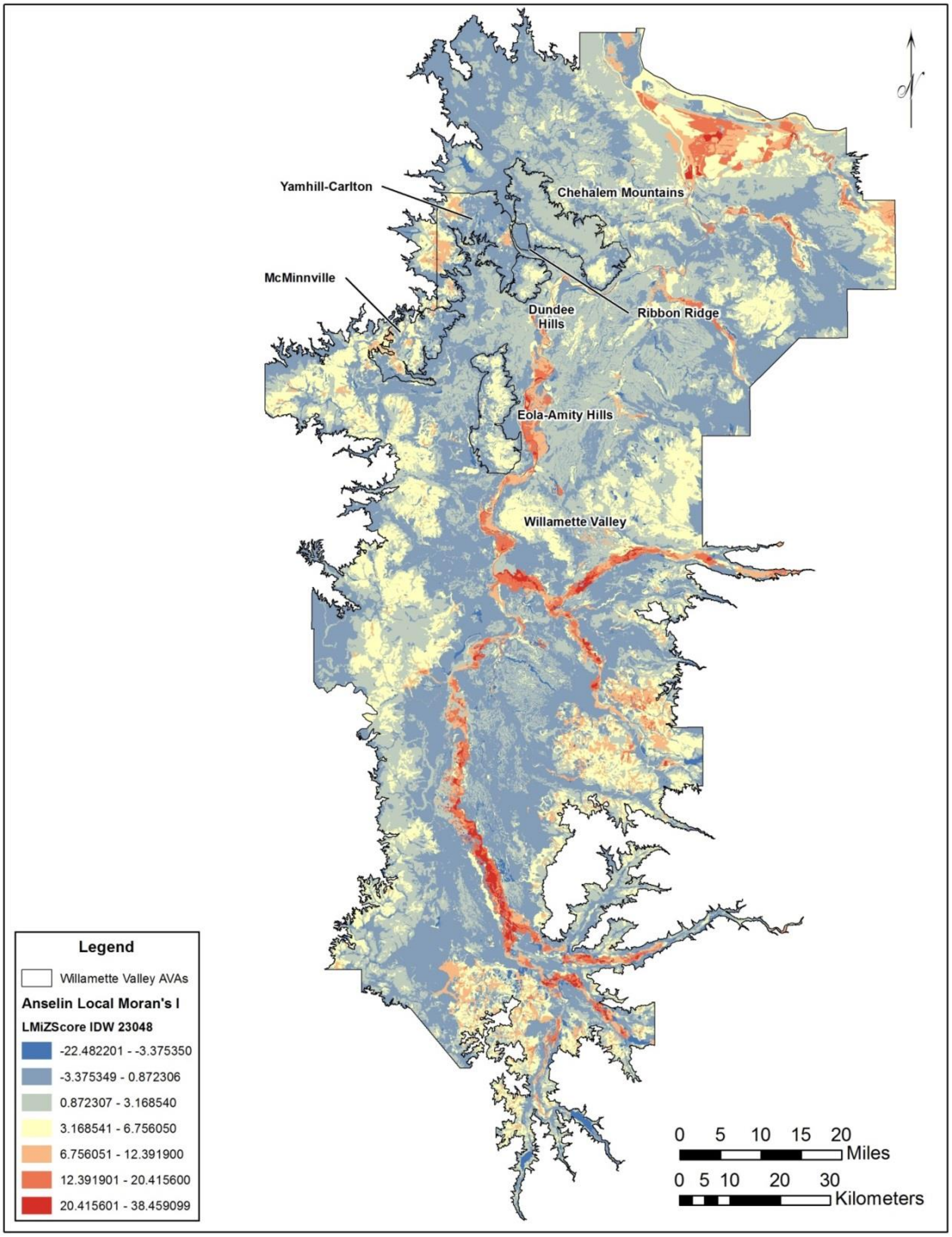

Figure A.1b – Anselin Local Moran's I: Z-Score of Clay Content in Willamette Valley AVA

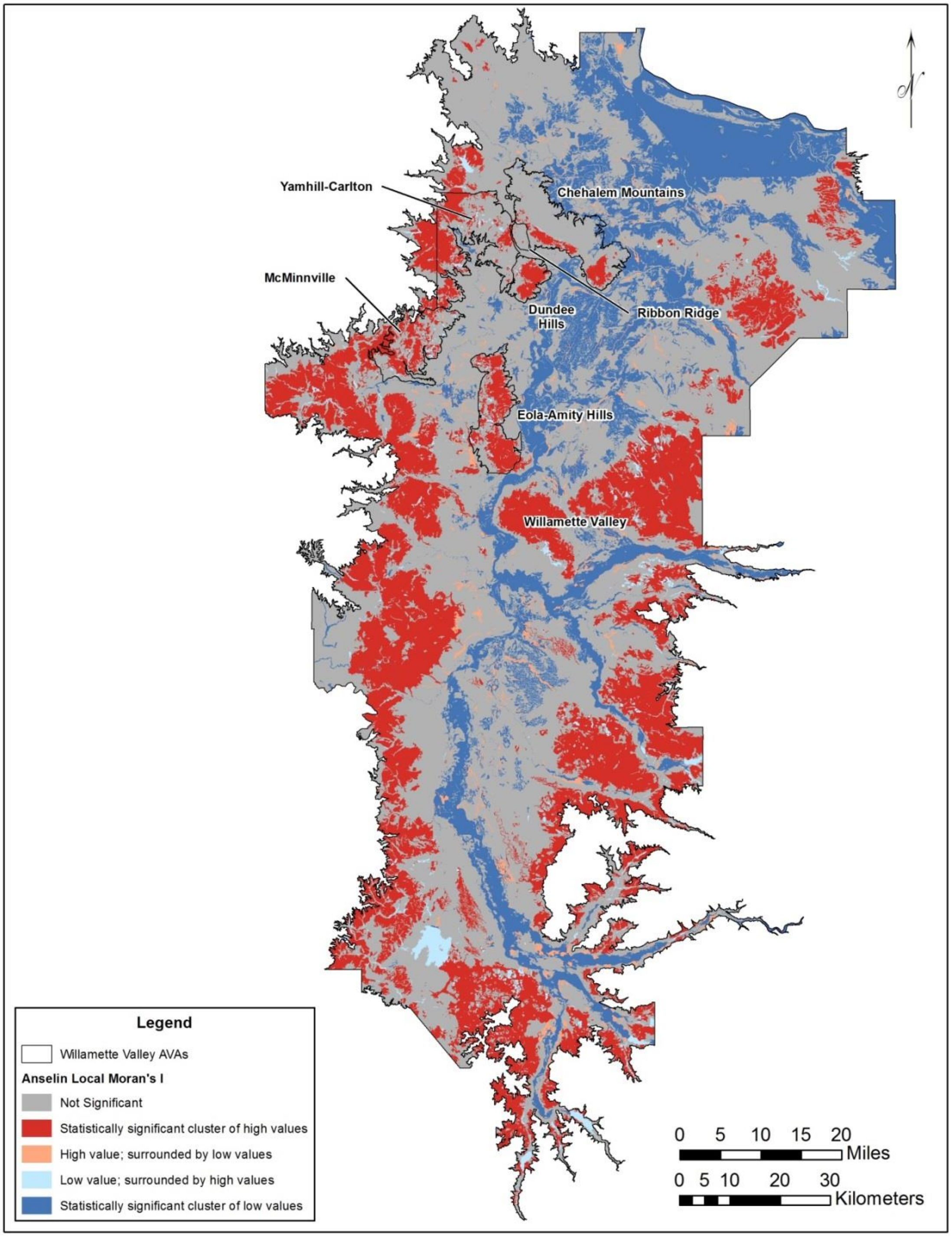

Figure A.1c – Significance of Anselin Local Moran's I of Clay Content in Willamette Valley AVA

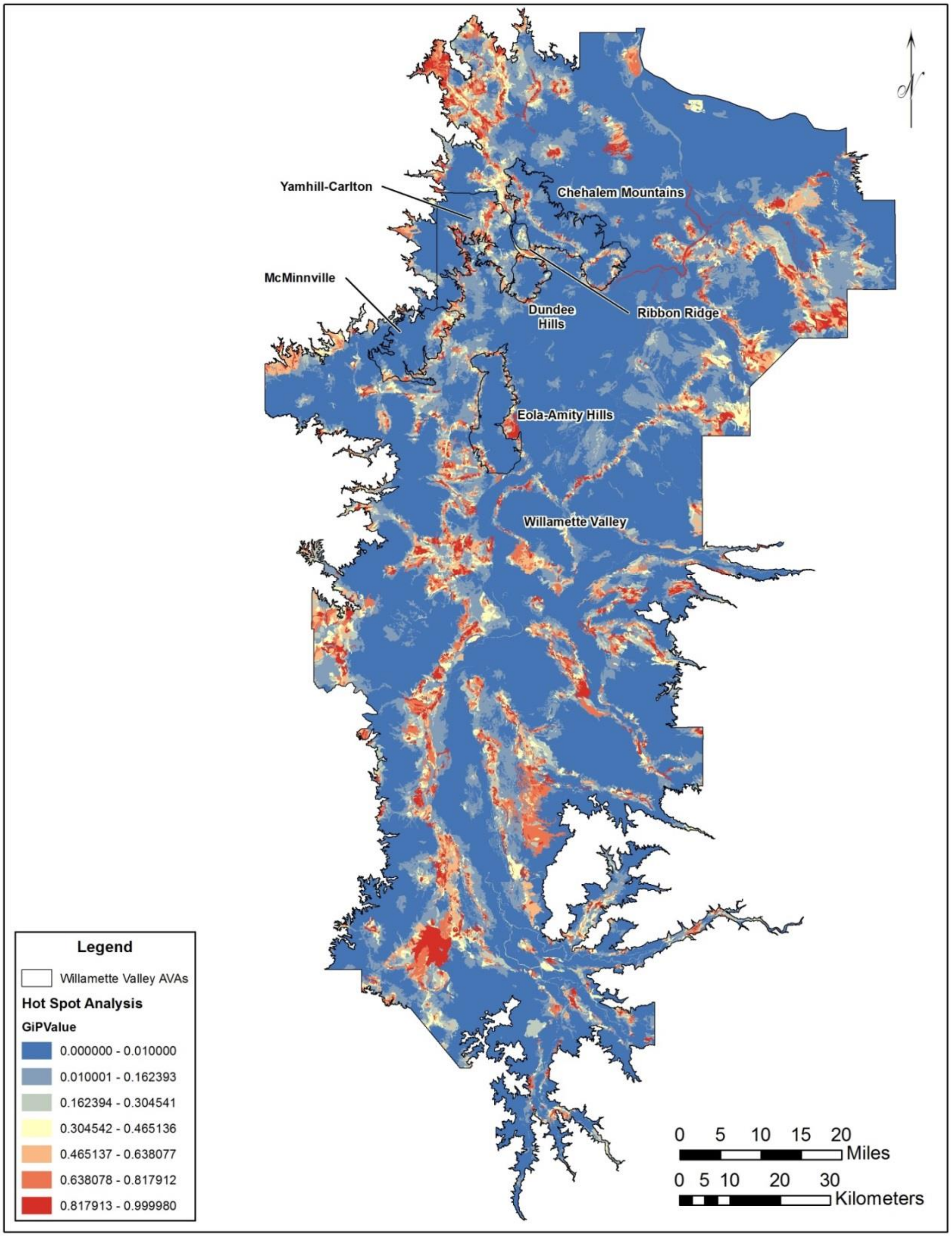

Figure A.2a – Hot Spot Analysis: P-Value of Clay Content in Willamette Valley AVA

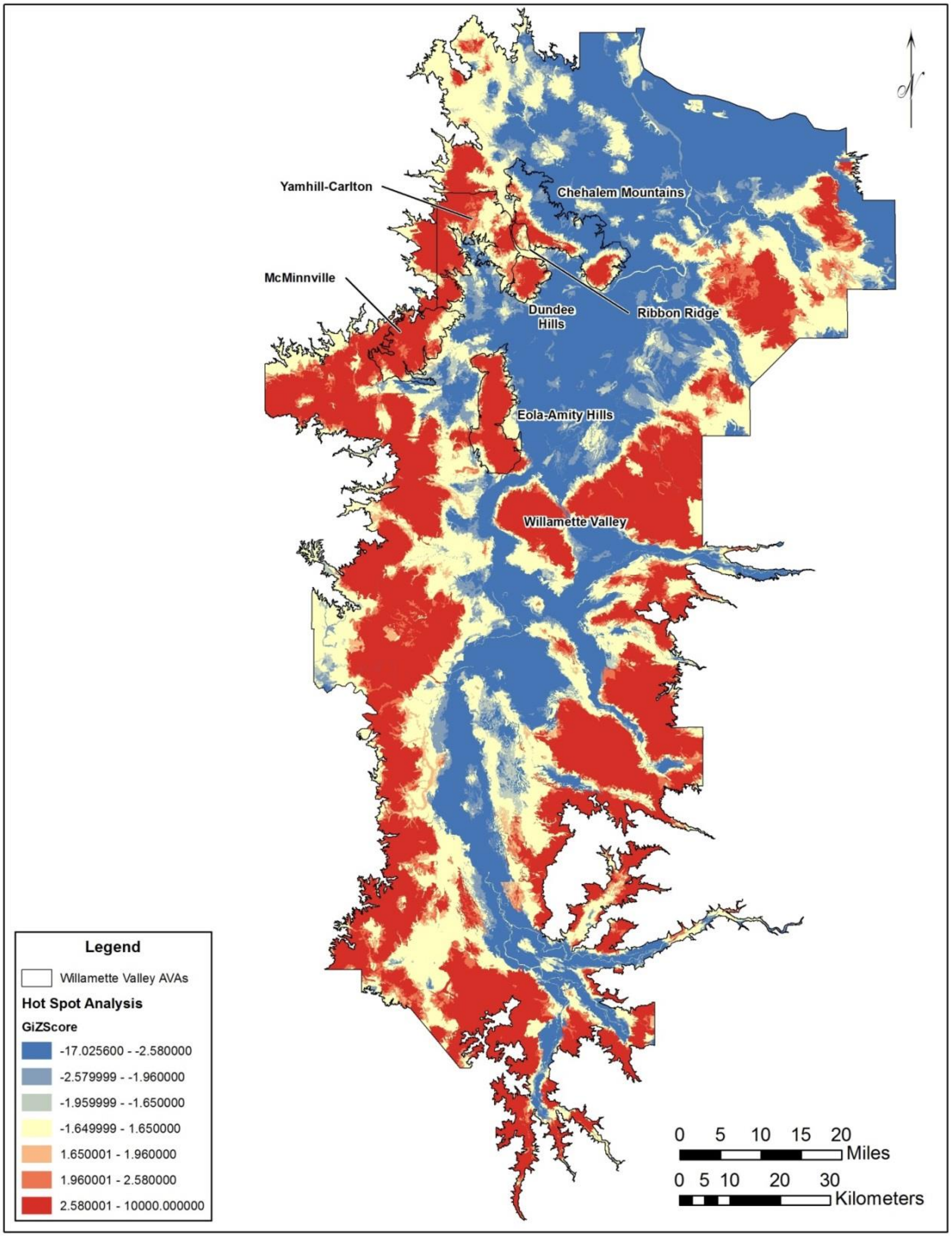

Figure A.2b – Hot Spot Analysis: Z-Score of Clay Content in Willamette Valley AVA