Consumer Ecoregions: Geographic Segmentation of the Western Conterminous United States of America

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A new partition of geographic regions in the Western US, based on environmental variables rather than political borders, is introduced as an alternative approach to aggregation of consumer demand data. The classification exercise described in this paper led to the definition of twelve distinct geographic regions representing the same area as seventeen corresponding western States. In comparison to the partition of States, these Consumer Ecoregions (CERs) demonstrate less variability in terms of population and economic output while representing distinct climates and landscapes and maintaining similar variability in terms of land area.

Keywords: consumer, geographic segmentation

INTRODUCTION

A foundational element in business analytics involves the quantification and, often, the geographic aggregation of consumer demand. Geographic data aggregation is typically based on US Postal Service ZIP Codes, political State and County boundaries, or US Census Bureau partitions. While Census Tracts, Block Groups or Core-Based Statistical Areas (CBSA) provide adequate spatial resolution for neighborhood or metropolitan level analyses, partitions using Census Divisions, Regions or State borders are often inadequate for understanding regional patterns of variability in business data, especially in cases where lurking environmental variables are influential. This paper presents a new geographic partition of the western conterminous United States of America to facilitate analysis of regional patterns in consumer demand when political borders are inappropriate.

The political portion of the conterminous United States is the most common map of the US and the most common geographic segmentation for data aggregation. Beginning in elementary school, young students are introduced to the 50 States and Washington D.C. and, as adults, we rarely question the utility of our political partition when applied to apolitical data. Unfortunately, these political borders are typically less than ideal for data aggregation or analysis of geographic patterns of variability in demographic, economic or business data especially when an influential lurking environmental variable is present.

This paper introduces a partition of Consumer Ecoregions (CERs) designed to facilitate a data aggregation alternative to State boundaries. The geographic focus in this initial effort is the western half of the conterminous United States. The CERs introduced are meant to serve as an alternative to 17 western States.

LITERATURE REVIEW

There have been a number of studies examining alternative geographic partitions in North America to illustrate patterns of cultural influence. Some popular non-fiction books (Garreau, 1981; Woodard, 2012) and others academic journal articless (Hawkins et al., 1980), use regional identity to explain the geographic distribution of North American culture. These publications imply geographic segmentation through the use of maps but borders are loosely defined and no data framework is provided to facilitate quantitative geographic data analysis. Instead, the regional structure provides a conceptual framework to identify locations in a general sense where shared history, culture and political orientation have come together to form distinct regions.

The marketing and consumer research literature have produced studies involving geographic segmentation. Most of these studies examine the interplay between psychographic and geographic segmentation (Lesser and Hughes, 1986; Kahle et al., 1992; Umesh, 1987). More recently, efforts have been made to validate market segments (Tonks, 2009) but, again, none of these studies attempt to define geographic segments or produce an alternative geographic partition for data analysis.

In a separate research thread, beginning in the latter half of the 20th century, the term "bioregionalism" emerged to represent a movement advocating political boundaries that are more congruent with ecological boundaries (McGinnis, 1999). The intention of the bioregionalism movement was to facilitate a regional governance structure more closely aligned with natural resources whereas my purpose in developing CERs is to provide a more useful way to aggregate demographic and economic data for business applications.

Finally, the US Environmental Protection Agency (EPA), led by Omernik (1987), embarked on an effort to develop a set of Ecoregions to provide a spatial framework for environmental resource management (Omernik and Griffith, 2014; McMahon et al., 2001). Indeed, EPA Ecoregions provide a useful road map and play a key role in shaping the partition of CERs.

DATA AND METHODS

The region classification exercise was driven by three objectives. First, using counties as the base unit of geography, I wanted to define fewer regions than States covering the same geographic area. When considering 50 separate entities, as we often do when reviewing State level statistics, it's difficult to focus on anything beyond the very top and the very bottom of any ranked list. I'd like to define no more than 30 CERs for the entire conterminous US and, for this exercise, fewer than 15 CERs for the Western US. Second, I wanted each region to be as distinct as possible from neighboring regions in terms of climate, landscape and, to a lesser extent, economics and consumer culture. In some cases this is straight forward (e.g., the Cascade Range makes an excellent border between the Pacific Northwest and the Columbia Plateau), but in other cases a State border is the best available dividing line (e.g., there is a distinct transition moving south from the Rocky Mountains into the Adobe Highlands but one could make the case for including portions of southern Colorado or northern New Mexico in one or the other region). Finally, I wanted regions within the partition to be similar, to the extent possible, in terms of size, population and economic activity. When viewing data through the lens of the 50 US States the land area differences between States like Texas (~269k sq mi) and Rhode Island (~1.2k sq mi) or the population differences between States like California (~40 million) and Wyoming (~0.6 million) or the economic differences between States like New York (~$1.75 trillion) and Vermont (~$0.035 trillion) are so vast as to make comparison nearly impossible if not invalid.

A variety of environmental, demographic and economic variables were analyzed and synthesized to arrive at this first formal iteration of CERs. To determine significant environmental differences and identify boundaries between regions, I examined temperature and precipitation data from the National Oceanic and Atmospheric Administration's Climate Normals for 1981-2010 (Arguez et al., 2012), the topographical patterns of large scale landscape features (USGS, 2020), the spatial extent of fresh water river networks (USGS 2019), direct incoming Solar Radiation (Sengupta et al., 2018) from the National Renewable Energy Lab and Ecoregions (Omernik, 1987) used by the EPA for environmental resource management. To

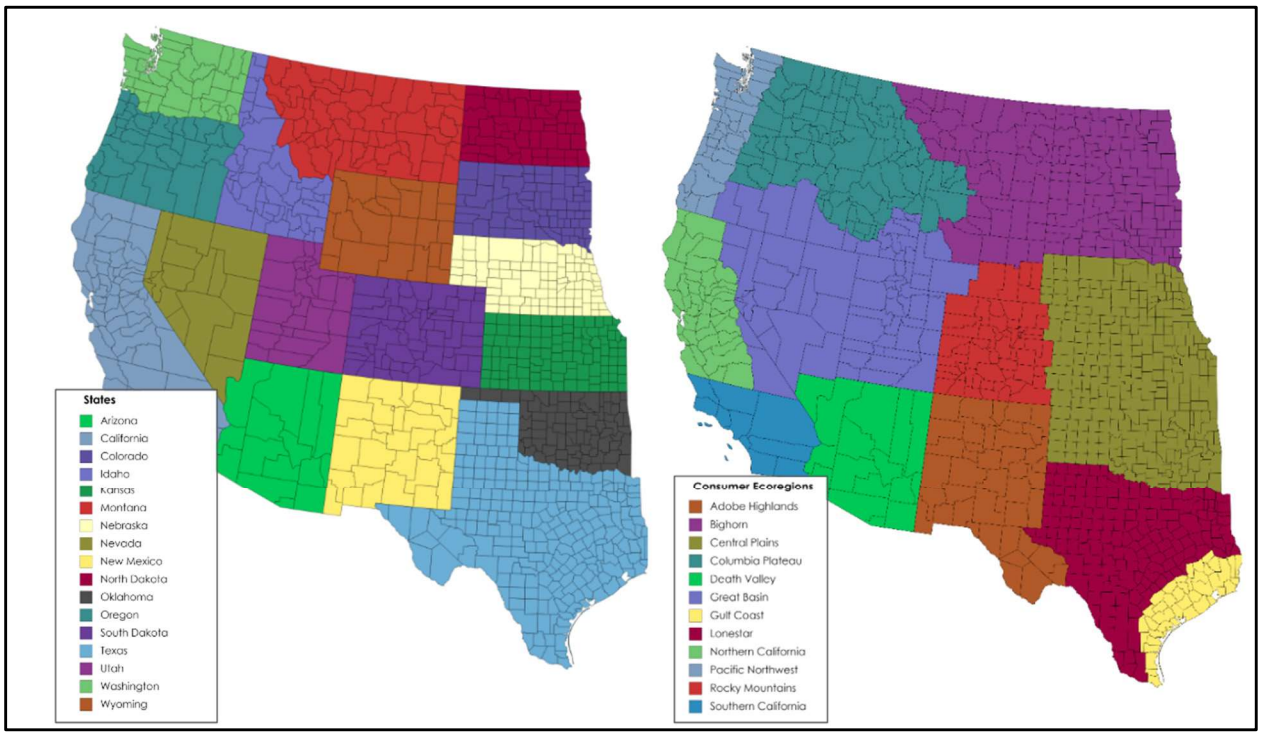
determine significant demographic and economic differences I utilized population estimates from the US Census Bureau's American Community Survey (2018) and local area gross domestic product (GDP) provided by the US Bureau of Economic Analysis (2019). Variables were viewed at the county level, when available, in map format to determine regional classifications based on visual assessment of natural borders and ecotones (Kark, 2013). State boundaries were also taken into consideration if a salient natural border wasn't obvious.

This classification exercise was data driven but decisions on where, exactly, to locate borders between individual counties were ultimately subjective in nature. Addressing and defending each specific individual border placement decision is beyond the scope of this paper.

CONSUMER ECOREGIONS

This classification exercise led to the definition of 12 separate CERs meant as an alternative to the 17 western States occupying the same geographic area. The 12 CERs are illustrated in Figure 1 and each region is described in the following paragraphs.

FIGURE 1
MAP OF THE WESTERN US & CORRESPONDING CONSUMER ECOREGIONS



The **Adobe Highlands** region is, essentially, the State of New Mexico plus several counties from west Texas. The climate in this high elevation region is arid with surplus solar radiation. Vegetation cover is primarily xerophytic flora. Mountains, mesas, rock canyons and desolate prairies combined with adobe style homes and structures create a distinct landscape. Major cities include Albuquerque, Santa Fe and El Paso.

The **Bighorn,** covering portions of Montana and Wyoming and all of North and South Dakota, has the second largest area of the CERs but contains the smallest population. The landscape is vast and relatively barren with grasslands and some forests. Winters can be frigid and the growing season relatively short but

the wide open plains are ideal for cattle ranching. There are no major population centers in the Bighorn but smaller cities include Billings, Casper, Rapid City, Sioux City and Fargo.

The **Central Plains** includes all of Nebraska, Kansas and Oklahoma plus the Texas Panhandle and a portion of eastern Colorado. Most of the region is dominated by agricultural production. The terrain is well suited to farming with relatively rich soil and level topography (Fonstad et al., 2003). Large urban areas are relatively few and far between but Omaha, Lincoln, Wichita, Topeka, Tulsa and Oklahoma City are the most prominent among them.

The **Columbia Plateau** contains parts of Washington, Oregon, Idaho, Montana and Wyoming. It is mountainous with both the Cascade Range and the Northern Rockies dominating the region. Population is low density and many acres of land are designated as National Parks or Forests. Spokane, Missoula and Boise are the region's largest urban areas.

Death Valley is an extremely hot and dry region, home to the Sonoran Desert, covering the State of Arizon and Clark County Nevada (Las Vegas). Summers bring blistering heat but winters are mild and pleasant. The landscape is home to saguaro cacti, scrub brush and not much else. Death Valley is home to a few large population centers including Phoenix, Tucson and Las Vegas.

The **Gulf Coast** region forms the southeastern border of Texas and the western shoreline of the Gulf of Mexico. The area is susceptible to hurricanes and major flood events. Summers can bring sweltering heat and humidity, while winters are relatively mild. Houston is the primary urban center in the region and the oil and gas business is the primary economic driver.

Lonestar is comprised entirely of counties from the State of Texas and includes areas known as Central Texas and Hill Country. Summers are hot and humid; winters are relatively mild. The region has a dynamic business community and several world-class Universities. Major metropolitan areas include San Antonio, Dallas, Austin and Fort Worth.

The **Great Basin** is a huge desolate region that sits at a relatively high elevation and contains portions of Nevada, Utah, Idaho, Oregon and California. The region has a small population, most of it concentrated in the Salt Lake City metropolitan area. The landscape is barren except for the Uintah and Wasatch mountains and the Great Salt Lake. Other urban centers include Pocatello to the north, Provo and St. George to the south, and Reno to the west.

Northern California has one of the largest populations and the second largest GDP thanks to Silicon Valley and the robust San Francisco bay area economy. In addition, the Sacramento Valley is part of Northern California adding agricultural productivity to the economy and inland heat to the otherwise cool temperatures prevalent near the Pacific coast. Landscapes vary from Mt. Shasta to rich agricultural fields to rugged cliffs, Redwood forests and rugged coastline.

The **Pacific Northwest** consists of the narrow strip of land adjacent to the Pacific Ocean and west of the Cascade Range in Oregon and Washington. The region is dominated by forest land and a wet and grey climate most of the year. Large urban areas have grown rapidly along the north-south Interstate 5 corridor between the Pudget Sound and the Willamette River valley. Major cities including Seattle, Tacoma, Portland and Eugene.

The **Rocky Mountains** region, covering most of Colorado and a portion of Wyoming is home to the greater Denver metropolitan area and cities north and south along the Front Range stretching from Laramie and Fort Collins to Colorado Springs and Pueblo. The region has four distinct seasons and clear, sunny skies with mountain views are nearly ubiquitous during cold winters, colorful springs, warm summers and crisp falls.

Finally, the **Southern California** region has the largest population and the largest economy despite being the second smallest of the twelve regions in terms of land area. Los Angeles and its sprawling urban and suburban landscape stretch from San Diego to Ventura and from Santa Monica to San Bernadino and beyond. The climate is mild with warm, dry summers and moderate temperatures year round. Sandy beaches and bustling freeways dominate the densely populated coastline, transitioning to desert scrub brush with palm trees as you move eastward.

RESULTS AND DISCUSSION

The resulting partition of CERs meets the objectives described above. The number of CERs is five fewer units than the corresponding seventeen States. The regions represent distinct climate zones within the western US. There is an inherent tradeoff between minimizing the number of regions and identifying meaningful boundaries between distinct climates but I think this partition represents a useful compromise. Finally, these regions are more consistent in terms of population, economy and land area as summarized for each CER in Figure 2.

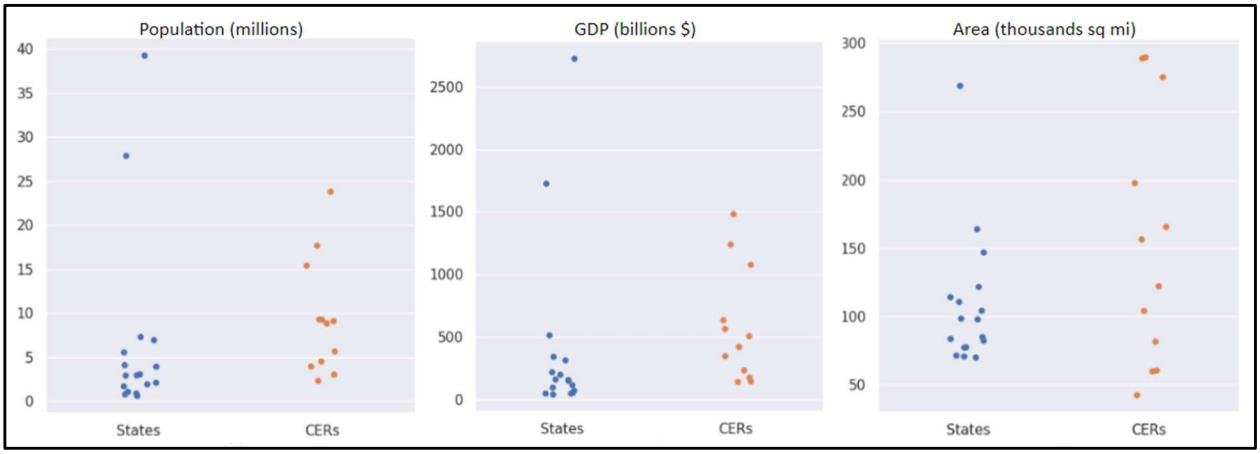
FIGURE 2
POPULATION, GDP AND AREA BY CONSUMER ECOREGION

Consumer Ecoregion	Population (2018)	GDP (thousands $)	Area (Sq Mi)
Adobe Highlands	3,024,126	142,967,066	156,311
Bighorn	2,309,775	138,907,766	288,700
Central Plains	9,251,675	504,949,195	274,880
Columbia Plateau	3,944,335	173,954,188	197,467
Death Valley	9,086,735	419,272,896	122,097
Great Basin	4,511,681	231,667,491	289,457
Gulf Coast	8,826,435	562,534,805	42,472
Lonestar	17,655,733	1,076,094,248	165,529
Northern California	15,377,728	1,238,016,163	81,529
Pacific Northwest	9,283,562	632,998,976	60,441
Rocky Mountains	5,638,233	345,339,693	103,991
Southern California	23,800,499	1,481,024,270	59,894

Sources: US Census Bureau (Population, Area) & US Bureau of Economic Analysis (GDP).

In comparison to the 17 States, the CERs are less variable in terms of population and economic output and a bit more variable in terms of land area as illustrated in Figure 3. Note the outliers represented by California and Texas in the "Population" and "GDP" columns in comparison to the more evenly distributed CERs. Under the "Area" column the CERs are larger on average, as necessary to reduce the number of regions, and have a wider range of sizes. The size differentiation in the western US is far less pronounced than in the eastern US where the tiniest States, like Rhode Island and Delaware, are located. The smallest of the 17 States in the western US is Oklahoma, which is larger than every State to the east other than Michigan and Minnesota.

FIGURE 3
DISTRIBUTION OF POPULATION, GDP AND LAND AREA



Another way to explore differences in variability is to calculate the coefficient of variation (Mendershausen, 1937) and compare the resulting coefficients from each group. As you can see in Figure 4, the coefficient of variation is significantly lower for CERs in Population and GDP than for the corresponding seventeen States. The variation in Area is fairly similar, though CERs have slightly higher variability than States in the Western US.

FIGURE 4
COEFFICIENT OF VARIATION FOR STATES AND CONSUMER ECOREGIONS

		Population	GDP	Area
States	Mean	5,710,525	352,010,383	91,179
	Standard Deviation	7,655,627	483,134,099	62,882
	Coefficient of Variation	**1.588**	**1.753**	**0.454**
CERs	Mean	8,670,040	534,440,520	141,751
	Standard Deviation	6,867,167	474,160,217	76,598
	Coefficient of Variation	**0.792**	**0.887**	**0.540**

There are several borders where State boundaries were utilized to separate two regions when no obvious natural border was more prominent or sufficiently concentrated in one area. This is the case in the border between the Adobe Highlands and the Rocky Mountains where the Colorado-New Mexico border works just as well as any other dividing line might. A similar situation presents itself along the eastern border of Southern California with Death Valley. If San Bernadino county wasn't so massive a more appropriate border between the city of San Bernadino and Palm Springs may have emerged but the California-Arizona border seemed more appropriate. The border between Death Valley and the Great Basin as well as the border between Lonestar and Great Plans were derived in similar fashion.

In contrast, there are several instances where natural borders are clearly more appropriate for segmentation of consumers. Traveling north from Southern California to Northern California the landscape transitions from desert to forest but the California-Oregon border is too far north to represent the difference in climate. In the northwest, the rainy western portions of Washington and Oregon have a lot more in

common with each other than they do with the higher and dryer region east of the Cascade Range. Other examples include the Northern Rockies usurping the boundaries of Idaho and Montana and the expansive Great Basin usurping the border between Nevada and Utah.

CONCLUSION

The broader goal of this research project is to develop a partition for the entire conterminous US and, eventually, for the North American continent. This paper represents the first step of many toward achieving that objective. Once a partition for the entire conterminous US is complete I plan to publish and make available the region-county assignment data for general use. I also anticipate publishing economic or business data aggregated by CER to highlight differences in patterns when using CERs versus States. Along the way I plan to conduct empirical studies using various data sources to test the relevance and effectiveness of border locations and region configurations. My hope is that useful insights regarding regional dynamics will be better illustrated using CERs and that these insights will lead to better location decisions and an improved understanding of American geography.

More generally, this research aims to bring attention to the relative poverty of options for increasing or decreasing spatial resolution when analyzing business or economic data. We are familiar with data analysis at high resolution in the temporal dimension, e.g., capturing stock market valuations and the market price of other securities or commodities aggregating by month, week, day, hour and even by the minute or second but we typically don't spend much time considering how analysis of data may be affected by different geographic aggregations. Hopefully this paper and future research will help create greater awareness of the spatial dimension and its relevance to business analytics.

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