REGIONAL PATTERNS OF ALKALINITY IN OREGON STREAMS: AN OVERVIEW OF ECOLOGICAL REGIONALIZATION

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REGIONAL PATTERNS OF ALKALINITY IN OREGON STREAMS: AN OVERVIEW OF ECOLOGICAL REGIONALIZATION

ABSTRACT: While many geographers believe that the regional concept is central to geographic study, no definitive regional scheme exists. The criteria considered in each regional study will relate to a stated objective or study. Ecological regionalization is a major contribution by geographers to environmental studies. By examining spatial patterns of factors key to ecological function, it is possible to delineate ecologically meaningful units (ecoregions). To further demonstrate the usefulness of ecoregions, a case study of alkalinity patterns in Oregon streams is described.

INTRODUCTION

"The highest form of the geographer's art is producing good regional geography." This was J.F. Hart's driving message in his presidential address delivered at the 77th annual meeting of the Association of American Geographers (Hart 1982). Hart's statement underscores what many geographers believe, that is, the regional concept is central to geographic study. One does not have to be a geographer to understand that there are distinct similarities and differences in features found on the earth's surface. But a geographer will try to make sense of the similarities and differences and bring them to some semblance of order for the purpose of further study. James (1952) tells us that seeking a more complete understanding of the face of the earth has been the continuous, unbroken theme of geographic study through the ages.

Geographers are in agreement that no definitive regional scheme exists. There are as many ways to divide the earth into regions as there are problems worth studying (James 1952). James refers to regions as "geographic generalizations." The criteria considered in each regional study will relate to a stated objective or problem.

The lack of agreement on what constitutes a region has led some geographers to question the validity of the regional concept as the core of geographical study. A particularly scathing condemnation of the regional concept and its inadequacies (Kimble 1952) generated much discussion of the topic by the geographers of that era (Minshull 1967). Kimble declared natural regions to be nonsense, described cultural regions as meaningless, and concluded that the regional concept is old-fashioned and unsatisfactory as a basis for geographical studies. Despite Kimble's admonitions, the regional approach has not only survived, but as evidenced by recent ecological regionalization efforts (ecoregions), it has flourished. Several Federal agencies, among them the U.S. Environmental Protection Agency (USEPA), are developing maps of ecoregions to give a spatial perspective to the complex task of managing and protecting our nation's resources. Although ecological regionalization schemes are currently attracting attention, the concept is not new.

This paper has evolved from efforts to trace the development of ecoregions and further demonstrate their usefulness. Specifically, the objectives of this paper are to: 1) discuss

the concept and development of ecological regionalization, 2) examine ecoregions as a major contribution by geographers to environmental research, and 3) demonstrate the utility of ecoregions for interpreting the spatial patterns of alkalinity values in Oregon streams. To accomplish these objectives, the paper first examines ecological regionalization in general terms, and then more specifically, recent ecological regionalization schemes in North America. A case study is then presented demonstrating the usefulness of ecoregions in understanding the spatial distribution of alkalinity values in streams.

ECOLOGICAL REGIONALIZATION

Development of Natural Regions

There have been many efforts to define "natural" regions in the history of geography. One of the earliest efforts on a global scale was by Herbertson (1905), who studied the distribution of different phenomena (climate and topography) integratively in the development of "major natural regions." Among the first attempts to divide the United States into natural regions were Allen's (1892) study of mammal distribution and Merriam's (1898) delineation of crop zones. Fenneman (1914) defined a hierarchy of physiographic units to determine regions within the United States and in 1943, Dice developed the concept of biotic provinces (Bailey et al. 1985). Most early attempts at natural regionalization were based on some combination of

structure and relief, climate, and vegetation (Joerg 1914). Anthropogenic factors such as land use were often eliminated from early studies on the basis that they only reflected the environment; they did not constitute it.

Joerg (1914) referred to natural regions as "units of investigation in modern geography." Most early attempts to delimit natural regions were for the purpose of discussion and explanation of the earth's physical features at an academic rather than applied level.

Development of Ecological Regionalization

Natural regions were the forerunners of today's ecological regionalization schemes. Ecological regionalization is one of the geographer's major contributions to environmental studies. Researchers in sciences other than geography have devised simpler single-feature regions such as for vegetation, soils, or climate, but these schemes fall short of the need for an integrated approach to resource assessment.

The need for ecoregions has grown out of the increased interest and awareness of environmental quality. Growing awareness of the fragility of our environment has prompted the enactment of various laws, acts, and policies designed to protect and enhance the ecological components that contribute to the quality of our natural resources (Nelson et al. 1978). Resource managers are being asked to account for total environmental impacts of their actions. For proper response to such

legislation, resource managers have found the need for a mechanism that would allow a better understanding of the integration of the social, biological, and physical components of ecosystems (Hughes et al. 1986).

The ecosystem concept regards the earth as a series of interrelated systems in which all components are linked (Bailey 1983). If one of the system's components is changed, a corresponding change can be expected in other components to which the initial component is linked. An ecosystem approach stresses the interrelationship among components rather than treating each one as a separate characteristic of the landscape. Ecoregions are delineated on the basis of the interrelatedness of ecosystems. Further knowledge of ecosystems allows resource managers to make more effective management decisions and policies.

Geographers and other environmental scientists have found a regional framework useful to gain additional understanding of regional patterns of ecosystem quality and the components that are associated with this quality. By examining spatial patterns of factors key to ecological functions, it is possible to delineate ecologically meaningful units (Omernik and Gallant 1986). Specifically, such ecoregions are delineated by examining mapped information for areas with commonality in factors that either cause regional variation in ecosystems, e.g., soils. climate, and physiography, or integrate these causal factors, e.g., land use (Omernik 1987). Since there is less variability

within ecoregions, they form logical frameworks from which to locate representative reference sites, design sampling schemes, analyze and evaluate data, assess regional patterns of attainable terrestrial and aquatic ecosystem quality, and report the results of those assessments (Rohm et al. 1987).

As with regions in general, there is no one "true" ecoregion. The many efforts of ecological regionalization are born out of the need for answers to specific natural resource questions. No one system is likely to prove suitable for all purposes.

Ecoregions in North America

Ecological regionalization has followed an evolutionary process, with much of the work done in Canada and the United States (Bailey et al. 1985). Canadians, for example, have developed several major ecological regionalization schemes, among them Hills' (1960) work defining the ecoregion concept, Crowley's (1967) research in biogeography, which led to the use of the term "ecoregion," Rowe's (1972) revision of Halliday's classification of forest regions in Canada, and Lacate's (1969) ecological land classification system.

Robert Bailey, a geographer with the U.S. Forest Service, is possibly the best known proponent of ecological regionalization in the United States. His 1976 map, Ecoregions of the United States, is an example of a broad-scale, multi-component, hierarchical approach to the delineation of meaningful ecological

units. In compiling this map, Bailey examined the following ecosystem components in hierarchical levels: vegetation, soils, and topography. At each successive level of the hierarchy a different ecosystem component is assigned prime importance in the placement of map boundaries.

Bailey has written extensively on the subject of ecological regionalization and his map is used by many agencies for the assessment of natural resources (e.g., Klopatek 1981, Fink and Edler 1982, Robertson and Wilson 1985). Some of the Federal agencies using Bailey's ecoregions include: U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management, U.S. Geological Survey, U.S. Environmental Protection Agency, National Aeronautic and Space Administration, and the Tennessee Valley Authority (Bailey 1986).

Another major ecological regionalization scheme was developed by the U.S. Department of Agriculture. In this effort, Austin (1972) used data for soils and climate to produce the Land Resource Regions map. The purpose of this map was to classify agricultural zones on a national and regional scale.

Omernik's Ecoregions of the Conterminous United States (1987) developed from efforts to classify streams in the United States for more effective water quality management (Larsen et al. 1986). Specifically, scientists at the Corvallis Environmental Research Laboratory of the USEPA were addressing the change in the direction of federal and state water quality programs. Traditionally, these programs focused on "water

pollution control." The new emphasis is on "attainable water quality," that is, what can be realistically expected (Larsen, et al. 1986).

Omernik based his approach on the hypothesis that ecosystems and their components reflect regional patterns and that these patterns can be perceived from mapped information (Omernik 1987). Omernik's ecoregions were delineated by relating factors that either cause variations in ecosystems or integrate causal factors on a regional basis. Maps depicting land use, land-surface form, potential natural vegetation, and soil were used to develop the ecoregion map. The map was compiled at two scales: 1:7,500,000 (national level) and 1:2,500,000 (regional level). The smaller-scale national map was intended to provide a general overview for broad-scale planning and analysis. The larger-scale, more detailed regional maps were intended to be used at the state and regional level. The regional maps distinguished between "most typical" and "generally typical" areas within each ecoregion. The most typical areas in an ecoregion were characterized by the class of each characteristic (land use, land-surface form, soil, and potential natural vegetation) predominant in that region and ultimately responsible for that ecoregion's homogeneity. The generally typical areas had fewer of the characteristics in common but still maintained the general integrity of that ecoregion (Larsen et al. 1986).

Selected Ecoregion Applications

The usefulness of Omernik's ecoregions as a tool in determining realistically attainable water quality has been demonstrated in cooperative research efforts between the EPA and various state agencies. The following is an overview of selected ecoregion studies. These studies suggest that there is less variability within Omernik's ecoregions than between them; hence, information from one part of the region could be extrapolated to the entire region.

Scientists from the Arkansas Department of Pollution Control and Ecology (ADPC&E) needed accurate measures of baseline chemical, physical, and biological conditions in streams throughout the state. Fish, physical habitat, and water quality data from 22 streams showed ecoregional differences. ADPC&E used ecoregions as a framework for measuring effects of impacts and a guide for setting appropriate water quality goals for Arkansas streams (Rohm et al. 1987).

The Ohio Environmental Protection Agency (OPEA) wanted to determine reasonably attainable water quality and biological integrity in Ohio streams. Ecoregions were used as a stream sample framework to provide a data base on attainable stream quality. Sampling included a variety of measurements that were used to identify regional patterns in fish assemblages and water chemistry (Whittier et al. 1987).

The Minnesota Pollution Control Agency (MPCA) used the ecoregional framework as a basis for several water quality

studies. The agency's analyses indicated distinct regional patterns and implied that attainable water quality varies regionally. As a result, the MPCA explored the possibility of using ecoregions to help determine realistically attainable goals for lake and stream resource management (MPCA 1986).

ALKALINITY PATTERNS IN OREGON STREAMS: A CASE STUDY

Discussion

This case study further demonstrates the usefulness of ecological regions in the study of environmental concerns. It also provides a more in-depth study of alkalinity patterns and the factors associated with these patterns. The study of alkalinity patterns in the United States has been a major segment of Environmental Research Laboratory - Corvallis's acid deposition research (Omernik and Powers 1983, Omernik and Griffith 1986). This case study is the first to integrate ecoregions and alkalinity data.

As stated earlier, ecoregions can provide a useful framework for examining realistically attainable water quality for aquatic resources. Streams that occur within any particular ecoregion should reflect the characteristics of the land they drain and therefore be relatively similar to one another in terms of water quality. Streams in different ecoregions should have different characteristics.

Alkalinity values in streams throughout Oregon were examined to determine if predictable patterns existed. Alkalinity was chosen as a parameter for two important reasons: data are readily available, and the measure is relatively stable temporally. Oregon is a desirable area to demonstrate the ecoregion approach due the wide variety of land use types and to the relatively large number (eight) of ecoregions having major portions located within the state (Figure 1).

Two specific questions asked in this case study are: (1) Do the available alkalinity data for Oregon streams reflect regional patterns that correspond with Omernik's ecoregions? (2) What factors appear to be associated with the within-ecoregion variances in alkalinity values? (Alkalinity patterns within an ecoregion are expected to be relatively similar; not identical). Answers to these questions may give further insight in the determination of realistic levels of attainable water quality in Oregon's streams.

Methods

Alkalinity data were gathered from STORET (an EPA water quality data base), base maps used in developing the Western Region Alkalinity Map (Omernik and Griffith 1986), and a recent field study of 99 sites throughout Oregon's ecoregions by ERL-Corvallis scientists. This combined database included over 1000 Oregon stream sites.

Ecoregion

1 Coast Range
2 Willamette Valley
3 Sierra Nevada
4 Cascades
5 Eastern Cascades
Slopes and Foothills
6 Columbia Basin
7 Blue Mountains
8 Snake River Basin/
High Desert

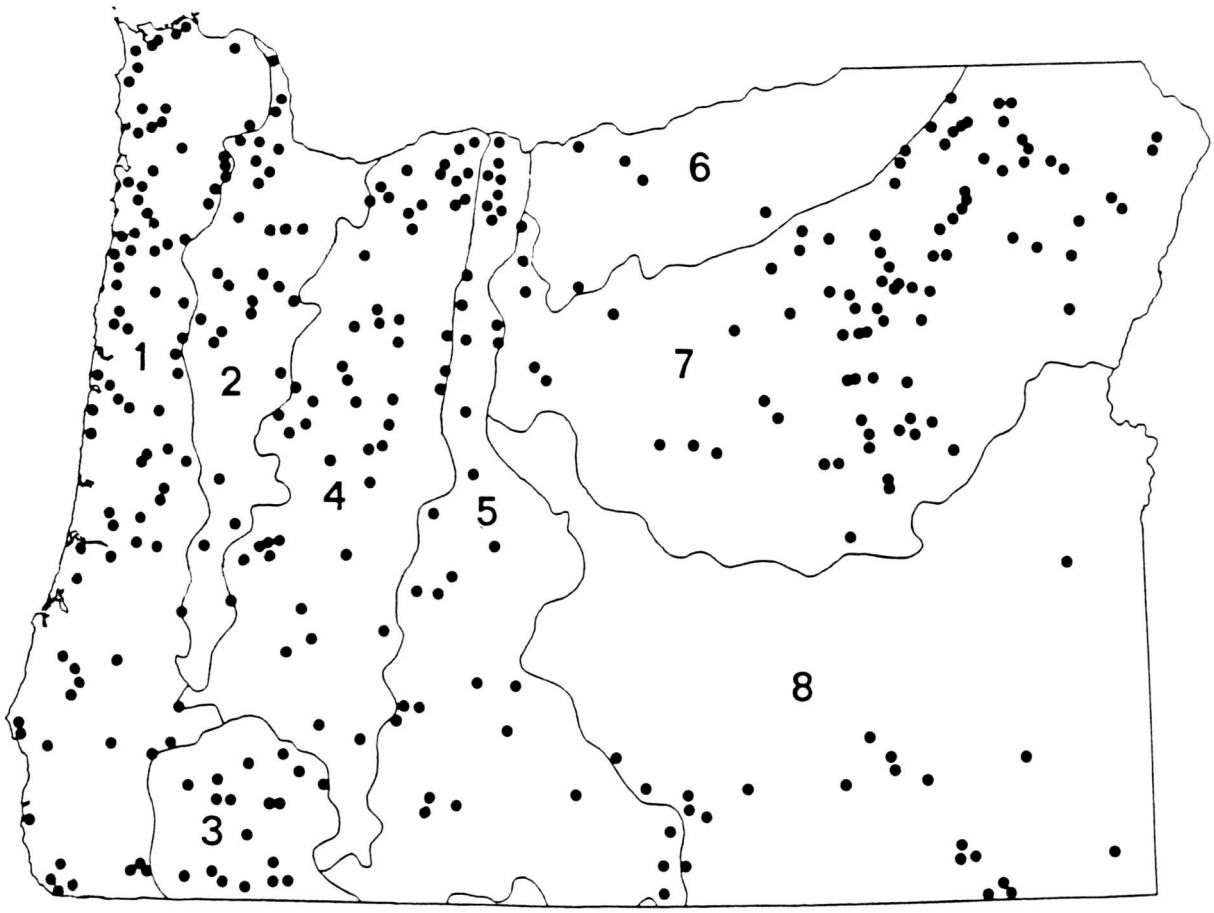
Figure 1. Ecoregions of Oregon (Omernik and Gallant 1986). Darker tones denote most typical areas.

To demonstrate the interaction of the regional watershed characteristics within each ecoregion, it was necessary to eliminate watersheds that overlapped ecoregion boundaries. Many of the routinely monitored Oregon rivers (e.g., Willamette and John Day) cross one or more ecoregion boundaries and were not appropriate for analysis in this study. Only 325 sites were located in watersheds completely within the eight ecoregions (Figure 2). These 325 sites were then plotted on a USGS 1:500,000 scale map of Oregon. Because there are more streams in humid areas, the sites were not equally divided amongst the ecoregions.

The watershed for each sample site was delineated and its area was measured. The alkalinity value for each site was converted to micro equivalents per liter, and the sites were color-coded to reflect the range of values. Examination of the color-coded map revealed groupings of sites with similar alkalinity values. These groupings were compared with maps of geology, soil type, land use, land-surface form, precipitation, elevation, and vegetation to reveal possible associations with alkalinity values.

Results

A visual inspection of medians and ranges of alkalinity values in the eight ecoregions suggests that sites draining watersheds with similar characteristics were more likely to have similar alkalinity values than those draining lands with



Ecoregion

1 Coast Range
2 Willamette Valley
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Slopes and Foothills
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7 Blue Mountains
8 Snake River Basin/
High Desert

Figure 2. Location of stream sites used in the study of alkalinity patterns in Oregon streams.

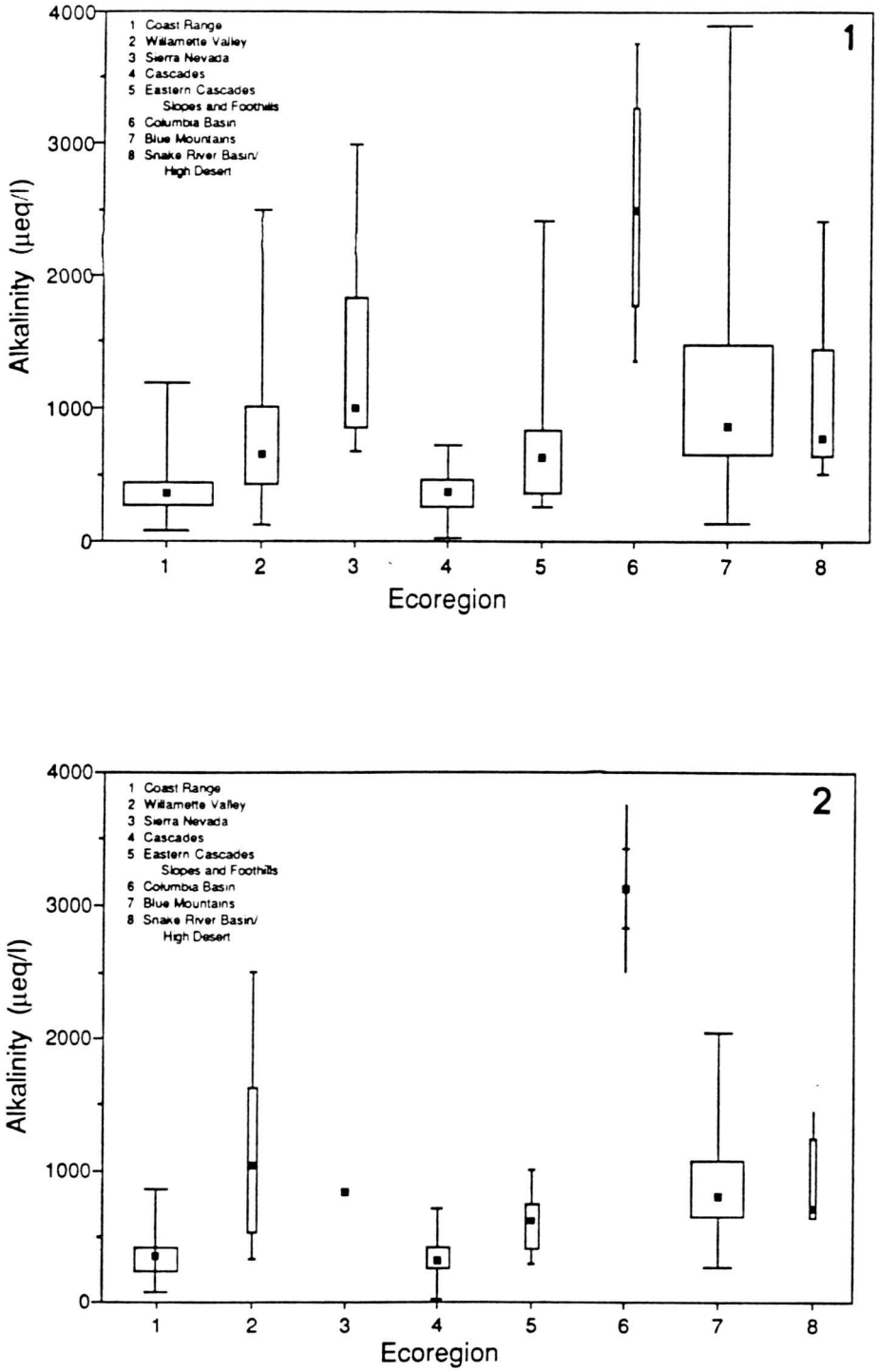

Figure 3. Box plots containing sample sizes, medians, ranges, and 25th and 75th percentiles of alkalinity values from Oregon ecoregions in general (1) and from the most typical portions of those ecoregions (2).

and Foothills sites range from 262 to 2420 μ/l. Alkalinity values of the 12 sites in the most typical portion of that ecoregion range from 298 to 1000 μ/l. The above example supports the notion that less variability is expected within the most typical portions of an ecoregion.

Various descriptive statistics associated with alkalinity values in each ecoregion are shown for all sites analyzed (Table A1) and for sites in the most typical portion of each ecoregion (Table A2). These tables are found in the Appendix.

An overview of the predominant characteristics (land-surface form, land use, potential natural vegetation, and soil) in each ecoregion is found in Table 1. A discussion of alkalinity patterns and the predominant characteristics in each ecoregion follows. The descriptions of Oregon's ecoregions are taken from Ecoregions of the Pacific Northwest (Omernik and Gallant 1986).

Regional Characteristics

Coast Range. This ecoregion is characterized by mountainous topography, dense coniferous forest, cool mountain soils, and very high levels of precipitation (over 100 inches/year in some areas). The high levels of precipitation and the mountainous terrain contribute to the many perennial streams in this ecoregion.

Alkalinity values of the 83 Coast Range sites range from 80 μ/l to 1180 μ/l. The median value is 404 μ/l. Eighty percent of the values fall between 250 and 600 μ/l. Seventy five

Table 1. Predominant characteristics of Ecoregions in Oregon (Omernik and Gallant 1986).

Ecoregion	Land-surface form	Potential natural vegetation	Land use	Soils
Coast Range	Low to high mountains	Spruce/cedar/hemlock, cedar/hemlock Douglas fir, redwood	Forest and woodland mostly ungrazed	Udic soils of high rainfall areas
Willamette Valley	Plains with hills of open hills	Cedar/hemlock/ Douglas fir, mosaic of Oregon oak woods and cedar/hemlock/ Douglas fir	Emphasis on cropland with some inter-spersion of pasture, woodland, and forest	Xeric Mollisols, Vertisols, and Allisols of interior valleys
Cascades	High mountains	Silver fir,/Douglas fir, fir/hemlock, western spruce/fir, Douglas fir, cedar/ hemlock/Douglas fir spruce/cedar/hemlock	Forest and woodland mostly ungrazed	Ultisols (Xerults)
Eastern Cascades Slopes and Foothills	Varied tablelands with moderate to high relief, plains with low mountains, open low mountains, high mountains	Western ponderosa pine	Forest and woodland grazed	Xeric soils of moderate rainfall areas
Columbia Basin	Varied irregular plains, tablelands with moderate to high relief, open hills (excludes extremes)	Wheatgrass/bluegrass, fescue/wheatgrass, sagebrush steppe (sagebrush, wheatgrass)	Mostly cropland, cropland with grazing land	Xerolls, Channeled Scablands
Blue Mountains	Low to high open mountains	Grand fir/Douglas fir, western ponderosa pine, western spruce/fir, Douglas fir	Forest and woodland grazed	Soils of eastern interior mountains, Mollisols, Inceptisols
Snake River Basin/ High Desert	Tablelands with moderate to high relief plains with hills of low mountains	Sagebrush steppe (sagebrush, wheat grass), saltbush/ greasewood	Desert shrubland grazed, some irrigated agriculture	Andisols, andic Mollisols

percent have values under 400 μ/l. Approximately 50 percent of the sites and their watersheds are located in the most typical portion of the ecoregion. There does not appear to be a marked difference in the alkalinity values of the most typical or generally typical portions of the Coast Range ecoregion. The high level of precipitation may be the dominant characteristic associated with the relatively low alkalinity values found in the Coast Range ecoregion.

Willamette Valley. Characterized by extensive agricultural activity, little or gradual relief, moderate to heavy precipitation, and valley soils, this ecoregion is the most heavily urbanized and industrialized in Oregon. Alkalinity values are expected to be relatively high in this ecoregion, given the general physical characteristics and the dominant land uses.

The 30 sample sites in the Willamette Valley ecoregion have alkalinity values ranging from 120 μ/l to 2500 μ/l with a median value of 655 μ/l. More than 75 percent of these sites have alkalinity concentrations greater than 400 μ/l. The eight sites in the extensively farmed most typical areas have a median value of 1050 μ/l. The lowest alkalinity concentrations are found in the higher elevations of the generally typical areas adjacent to the more mountainous ecoregions.

Sierra Nevada. The relatively high alkalinity values found in the Sierra Nevada ecoregion are not consistent with the expected low alkalinity values of mountainous ecoregions. In

Oregon, only ten percent of this ecoregion is most typical. Eighteen of the 20 sites are located in the generally typical portion of the ecoregion, and therefore, are not reflective of the most typical characteristics.

The twenty sites in the Sierra Nevada ecoregion have alkalinity values ranging from 680 μ/l to 3000 μ/l. The median value is 1000 μ/l. This is high compared to the median alkalinity values of the Coast Range (363 μ/l) and Cascades (370 μ/l) ecoregions. The higher alkalinity values found in this ecoregion may be associated with the wide variations in geology or the presence of agricultural activity in the intermountain valleys. Cultivation of orchards is extensive in the Rogue River Valley.

Cascades. This ecoregion is characterized by high mountains; heavy precipitation; cool, acidic soils; and dense coniferous forests. The most typical portion of the Cascades ecoregion includes the older, basaltic mountains of the western Cascade Range. These steep, densely forested slopes have acidic soils and high levels of precipitation. Forest-related land uses such as silviculture and recreation are found throughout the most typical portion of the ecoregion. Ninety-five percent of this portion of the ecoregion is held in the public domain.

This ecoregion has the narrowest range of alkalinity measure in Oregon. Alkalinity values of the forty-nine sites in the Cascades ecoregion range from 28 μ/l to 720 μ/l. The median is 370 μ/l. The Cascades ecoregion has all of the characteristics

associated with low levels of alkalinity. Streams draining watersheds within this ecoregion are expected to exhibit low alkalinity values. Almost half the sample sites in this ecoregion are located in the most typical portion.

Eastern Cascades Slopes and Foothills. This ecoregion is bordered on the west by the mountainous Cascades ecoregion and on the east by three arid ecoregions. Within this transitional region, the landscape varies from high forested peaks to open sagebrush plains, the precipitation ranges from high to low, soils range from moist to arid types, and the geology varies considerably. The most typical portions of the Eastern Cascades Slopes and Foothills are characterized by high relief tablelands and low mountains, cool soils, coniferous forests, low to moderate precipitation, and grazed woodlands and forests. Alkalinity values of the 35 sites in the Eastern Cascade Slopes and Foothills range from 262 μ/l to 2420 μ/l. The median alkalinity value for this ecoregion is 686 μ/l. In general, the lower alkalinity concentrations are found in streams adjacent to the Cascades ecoregion to the west. The higher alkalinity values are found in areas of agricultural activity and in areas adjacent to the more arid ecoregions to the east.

Columbia Basin. This ecoregion is characterized by extensive agricultural activity, low to moderate precipitation, arid soils, and grasslands/desert vegetation. The landform is comprised of low mountains and high tablelands with some open plains. The majority of the streams originating within the

Columbia Basin ecoregion are intermittent or ephemeral. Water from perennial streams in this ecoregion is generally diverted for irrigation purposes.

Alkalinity values of the five sites in the Columbia Basin ecoregion range from 1380 μ/l to 3750 μ/l with a median value of 2500 μ/l. The general characteristics found in the Columbia Basin ecoregion all have strong associations with higher levels of alkalinity. Although data was available for only five sites in this ecoregion, all five have high alkalinity values.

Blue Mountains. Significant contrasts in soil, land surface form, vegetation, and geology are apparent within the Blue Mountain ecoregion. Included in this diverse ecoregion are extremes ranging from high, glaciated peaks to arid, desert-like environments. Perennial streams draining small watersheds are abundant in the mountainous portions of the Blue Mountains ecoregion. The intermountain valleys and grasslands are drained by large river systems such as the John Day and Powder Rivers. More than half of the Blue Mountains ecoregion is public domain.

The most typical portions of the Blue Mountains ecoregion are characterized by mountainous topography, coniferous forests, cool mountain soils, moderate precipitation, and a variety of geologic formations and rock types. With the exception of the high, glaciated peaks found in the Wallowa Mountains, all the mountain ranges in the Blue Mountains ecoregion are designated as most typical. The primary land uses are cattle grazing, silviculture, and recreation.

Of the ecoregions in Oregon, the Blue Mountains ecoregion exhibits the greatest range of alkalinity values and the most sites. The 84 sites have alkalinity values ranging from 140 μ/l to 3900 μ/l with a median value of 860 μ/l. Seventy percent of the sites sampled have moderate levels of alkalinity concentrations (500 μ/l to 1500 μ/l). The highest alkalinity values are found in the farmed, western portion of the ecoregion and the lowest alkalinity concentrations are found in the streams draining the small watersheds of the high, glaciated peaks.

Snake River Basin/High Desert. This ecoregion is characterized by basin and range topography, low precipitation, arid soils, and desert vegetation. The land is used primarily for open rangeland grazing although some pockets of irrigated cropland exist.

The Snake River Basin/High Desert ecoregion is the largest and most arid. The nineteen sample sites found in the Snake River Basin/High Desert ecoregion have alkalinity values ranging from 510 μ/l to 2420 μ/l with a median value of 780 μ/l. The characteristics of this ecoregion are those associated with relatively high alkalinity values.

SUMMARY

The results from this study suggest that streams within an ecoregion tend to have similar alkalinity values. The ecoregions with distinctly different characteristics have more distinct

alkalinity values; transitional ecoregions exhibit a wider range of alkalinity values. Ecoregions may prove useful to resource managers in Oregon as they attempt to determine attainable water quality levels. For example, studies of other parameters affecting or being affected by water quality levels (i.e., phosphorous, dissolved oxygen, species richness of fish) would be useful complements to this case study.

As ecological regionalization schemes develop and are used in the spatial analyses of data and display that data in mapped form, we as geographers, must be wary of misinterpretation and misuse. Ecoregions will not bring immediate order to all environmental concerns; they simply provide a useful tool to further understand our environment in a regional context where a certain degree of homogeneity within a defined region can be expected. Even the most well defined regions exhibit some degree of heterogeneity.

Fenneman (1914) in summing up an ideal region, stated that the best regions are those that allow the largest possible number of general statements before details and exceptions become necessary. In developing ecological regionalization schemes, Fenneman's ideal should be the ultimate goal. In living up to his standard, geographers will better understand the processes and components that integrate to form an ecoregion.

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APPENDIX

Table A1. Descriptive statistics for alkalinity values of streams in Oregon Ecoregions

Ecoregion	Number of Sites	Median (µeq/l)	Mean (µeq/l)	Range (µeq/l)	Standard Deviation	Coefficient of Variation
Coast Range	83	363	404	80-1,180	199	0.49
Willamette Valley	30	655	777	120-2,500	525	0.68
Sierra Nevada	20	1,000	1,338	680-3,000	699	0.52
Cascades	49	370	377	28-720	163	0.43
Eastern Cascades Slopes and Foothills	35	686	713	262-2,420	463	0.64
Columbia Basin	5	2,500	2.526	1,380-3,750	774	0.31
Blue Mountains	84	860	1,187	140-3,900	850	0.71
Snake River Basin/ High Desert	19	780	1,061	510-2,420	564	0.53

Table A2. Descriptive statistics for alkalinity values of streams in the most typical portion of Oregon Ecoregions

Ecoregion	Number of Sites	Median (µeq/l)	Mean (µeq/l)	Range (µeq/l)	Standard Deviation	Coefficient of Variation
Coast Range	40	346	353	80-867	147	0.42
Willamette Valley	8	1,050	1,162	340-2,500	666	0.57
Sierra Nevada	2	838	838	832-844	6	0.01
Cascades	20	320	346	28-720	157	0.45
Eastern Cascades Slopes and Foothills	12	613	609	298-1,000	206	0.34
Columbia Basin	2	3,125	3,125	2,500-3,750	625	0.20
Blue Mountains	49	812	924	267-2,040	431	0.47
Snake River Basin/ High Desert	4	720	882	640-1,448	329	0.37