

# **Testing Human Wellbeing Indicators and Life Satisfaction: A Pilot Study using Google Insights**

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The logo for the Puget Sound Institute is a horizontal rectangle divided into two equal halves. The left half is a solid purple color, and the right half is a solid dark grey or black color. The words "PUGET SOUND" are written in white, uppercase, serif font on the purple background, and the word "INSTITUTE" is written in white, uppercase, serif font on the dark grey background.

**PUGET SOUND INSTITUTE**

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## Summary

The Puget Sound Partnership has been tasked with coordinating the recovery of the Puget Sound for, among other things, human health and quality of life. The attainment of these goals is generally measured through Vital Signs, although there are few tested metrics for human wellbeing and quality of life related to the natural environment.

In this paper, we present pilot results for 13 proposed vital sign indicators (Box 1) and demonstrate the use of Google Consumer Insights Surveys in combination with multivariate analysis as a method of monitoring human wellbeing over time. Using results from 4,418 respondents to an online survey conducted in June of 2014, we describe the relationship between overall life satisfaction (a standard global measure for subjective wellbeing) and each indicator; estimate the status of each indicator across age, income, gender, and geographic subregion of the Puget Sound; and identify the dominant groupings of indicators.

We found that individually, eleven of the thirteen indicators have a small but positive correlation to overall life satisfaction. More importantly, however, we found that many of the indicators correlated to other indicators, resulting in factor groupings of human wellbeing predictors (Box 1). These groupings largely represent the recommended Vital Signs to the Puget Sound Partnership and demonstrate that there is internal reliability among the indicators in each group: if one of the indicators within a factor measures highly, the other(s) will too.

Males score significantly higher on Sense of Place, Outdoor Activities, and Good Governance factors. Rural populations have significantly more natural resource access than suburban and urban populations. And older adults (45-54) report significantly lower sense of place, higher natural resource access, and lower trust in governance. Participation in cultural activities is highest for younger (18-24) and older (45-54) populations.

Lastly, four of the six factors significantly predicted overall life satisfaction: Cultural Activities, Good Governance, Sense of Place, and Outdoor Activities.

### Box 1: 13 Indicators Tested and Resulting Factors

#### Sense of Place

1. Attachment to Puget Sound
2. Identification with Puget Sound

#### Psychological Wellbeing

3. Inspired by time spent outdoors
4. Reduced stress after time spent outdoors

#### Outdoor Activities

5. Frequency of winter outdoor recreation
6. Frequency of summer outdoor recreation
7. Frequency of outdoor activity with family

#### Resource Access

8. Frequency of wild local resource gathering
9. Ability to access wild local resources

#### Cultural Activities

10. Participation in communal activities
11. Participation in stewardship

#### Good Governance

12. Trust in policymakers
13. Trust in scientific experts

\*Overall life satisfaction

## Background

The Puget Sound Partnership has been tasked with coordinating the recovery of the Puget Sound for, among other things, human health and quality of life. The attainment of these goals is generally measured through Vital Signs, although the originally-adopted Vital Signs had very few metrics of human health and wellbeing. A two-year process resulted in 9 recommended human health and wellbeing Vital Signs for adoption in the summer of 2015: Onsite Sewage (previously adopted), Shellfish beds (previously adopted), Air quality, Drinking water, Local foods, Outdoor Activity, Cultural Wellbeing, Sense of Place, Good Governance, Sound Stewardship (previously adopted) and Economic Vitality. While data on some of these indicators are readily available (e.g., onsite sewage, shellfish beds, and air quality), the Partnership continues to lack data and metrics for many of these high priority indicators of success.

Human wellbeing can be measured using a variety of metrics. Some well-established objective metrics include GDP, average life expectancy, and literacy rates. Well-established subjective metrics include Life Satisfaction questions. Metrics of human wellbeing that specifically relate to the natural environment, however, are not well established, nor have methods for collecting subjective data associated with the natural environment been widely tested.

## Methods

### Survey Design

We implemented a multiple matrix survey design (Thomas et al 2006; Gonzalez and Eltinge 2007). Whereas traditional surveys apply a large number of questions to a relatively small population (or else require vast amounts of funding and resources), a “multi-matrix” design allows a large sample size with minimal resources by asking each respondent just a few questions and using correlation to impute responses for empty cells (Raghunathan and Grizzle 1995). This represents considerable resource savings, since not every respondent needs to be asked every question. It also is important to note that shorter questionnaires are not necessarily second-best to long questionnaires, even independent of all other factors. Long surveys can have adverse effects on data quality (Herzog and Bachman 1981; Johnson et al. 1974; Kraut et al. 1975; Shields and To 2005) and response rates (Burchell and Marsh 1992; Groves et al. 2000).

Multiple matrix designs work best when there is strong correlation between questions such that responses to one question can reliably predict responses to another question. To generate an effective multiple matrix design, we first conducted a pilot study with undergraduate environmental studies students at the University of Washington Tacoma. 40 students were asked to respond to all 15 questions (APPENDIX I) that constituted the multiple matrix design. We then analyzed the correlation between responses, and developed an algorithm for generating a design with 24 different micro-surveys of six questions each that sought to minimize the correlation between questions asked within the same micro-survey and maximize the correlation between questions not asked within the same survey (to maximize predictive power for the missing responses in the multiple matrix design), constraining placement to minimize the number of co-occurrences and ensure that each question is asked a sufficient number of times. Since the first two questions of each microsurvey were the same (General Life Satisfaction and

Time Lived in Puget Sound), this meant that the remaining 13 questions were assigned to positions 3-6 for the 24 microsurveys. The block design is presented in APPENDIX II.

## Survey Tool

We contracted with Google Consumer Insights (GCS) to produce approximately 180 responses for each microsurvey (such that each question would have at least 1000 responses) from respondents across the Puget Sound. As the name implies, GCS primarily services marketing research; however, it has numerous advantages in terms of expediency, affordability, and cost control, and thus this paper also serves to demonstrate how GCS can be used for monitoring purposes. GCS recruits respondents from the population of users for Google’s web-based and mobile products. While the service continues to evolve as Google’s technical capabilities increase, at the time of our survey implementation responses were generated from individuals seeking premium Internet content such as news articles, games, videos, and music. The basic framework of GCS is that web publishers sign up with GCS to host surveys that serve as a “wall” to content access; Google then pays these publishers for hosting Consumer Surveys (MacDonald et al. 2011). Respondents are asked to complete a survey in order to access premium content from participating publishers. Two immediate practical advantages of this approach are that our survey is non-intrusive (since respondents were going to answer survey questions of one form or another) and reciprocal, in that respondents receive benefits in exchange for their participation. MacDonald et al. (2011) speak to the benefits of using shorter GCS microsurveys, noting that GCS has an average of about 16.75 percent response rate (MacDonald et al. 2011), as compared to a 1% average for most Internet surveys (Lavrakas 2010), 7-14% for telephone surveys (Pew 2011, Pew 2012), and 15% for Internet panels (Gallup 2012).

Another component that makes GCS an expedient and affordable survey option is that instead of asking demographic questions as part of the survey, GCS infers demographic and geographic data using IP addresses and web histories. Table 1 shows how GCS computes different demographic data:

*Table 1: GCS Inference Methods for Demographic Data*

Variable	Inference Method
Location	nearest city based upon IP address
Urban Density	census tract data associated with inferred location
Income	census tract data associated with inferred location
Gender	Google-associated web history
Age Group	Google-associated web history

GCS uses the inferred demographic data shown in Table 1 to stratify its sampling protocol. Stratification of the target population is based upon the Current Population Survey Internet Use supplement (MacDonald et al. 2011); GCS infers the demographic data of potential respondents

in real time and then allocates respondents to surveys based upon these inferred demographics in order to optimally allocate respondents in terms of questions and strata (MacDonald et al. 2011).

MacDonald et al. (2011) demonstrate that the representativeness and accuracy of GCS compares quite favorably with probabilistic and non-probabilistic panel Internet surveys; however, one potential remaining concern with the use of GCS for policy-related research is the extent to which target population from which GCS samples--Internet users--reflects the overall US population. As Internet use becomes increasingly ubiquitous, this problem is lessening, but in 2011 the Pew Foundation found that Internet users are on average younger, more educated, and of higher income than the general population (Pew 2011). It is important to note that this issue is not unique to Internet surveys--phone and mail surveys can encounter similar challenges. To combat this issue, we use post-stratification weights based upon the most recent American Community Survey (ACS) (described below) to weight responses in accordance to the population of interest (in this case, residents of the Puget Sound region of Washington State). Surveys were only administered to respondents with IP addresses that were located within the target region of zipcode prefixes from 980-983.

## Data Analysis

### Response Rates

GCS measures response rates by dividing the number of completed surveys over the number of “impressions.” An impression is when the user views the survey and the survey question. The response rate then reflects the number of survey completions out of the number of attempts made to elicit a completed survey. Since our design implements 24 different microsurveys, there are 24 different response rates: these range from 36% to 51%, with a median of 43%. In total, of the 10,291 individuals who viewed any of the 24 microsurveys, 4,418 completed all 6 questions, for an overall response rate of 43%.

### Cleaning and Weighting

Since our research concerns the general Puget Sound population, not the population of Internet users in Puget Sound, the GCS has some limitations in being applied to inference across Puget Sound (See Appendix III for respondent representation). To address these issues, we developed two post-stratification weighting methodologies. In the first, we used the ACS to weight by age and gender over the Puget Sound Region. These weights were created using a cross tabulation of ages and genders in the entire sample area. In the second method, we post stratified by age, gender and county groups for individuals between 18 and 55. These weights were produced by summarizing ACS data concerning gender and age from the 12 target counties and using the cross-tabulated proportions from these data to compute weights. We used the former weights for inference across Puget Sound while we used the latter for small area and domain estimation. By weighting survey responses, we were able to generate more generalizable findings that suitably account for demographic discrepancies between our pool of respondents and the general population.



## Multiple Imputation

Along with weighting, a second key component of our data analysis was to impute missing responses produced by the multiple matrix survey design. Because respondents were not asked every question, we used multiple imputation (Rubin 1987) to estimate responses based upon observed responses and inferred demographic data. The basic premise of multiple imputation is that missing data can be simulated by sampling from the predictive distribution of the missing value (Reiter and Raghunathan 2007); these samples serve to essentially generate many “complete” data sets. The point and variance estimates from each imputed data set were then combined to facilitate statistical inference via complete-data methods (Rubin 1987).

One advantage of this approach, relative to many other multiple imputation applications, is that we can be confident that data are, in fact, missing at random (because certain questions were not assigned to certain respondents). This means that non-respondents for a given question are not expected to differ in substantive, unobserved ways from respondents, since missing data points in our case do not indicate that a given respondent refused or neglected to answer the question. In fact, our data are thus said to be “Missing Completely at Random” (Carpenter and Kenward 2013). The primary implication of this is that the observed data can be considered representative of the sample population.

## Results

### Individual Indicators Significantly but Minimally Correlate to Life Satisfaction

To get a basic understanding of how each potential indicator related to a general metric of subjective wellbeing, we examined the correlation between each indicator and the life satisfaction variable. Because both the independent variables and the dependent variable are categorical ordinal variables, standard correlation metrics such as Pearson’s product-moment correlation are inappropriate (Chen and Popovich 2002, Poon et al. 2002). Instead, we used polychoric correlation (Olsson 1979).

Eleven of the thirteen indicators had a statistically significant bivariate correlation with life satisfaction (Table 2). The five indicators with a positive correlation figure above 0.1 to subjective wellbeing were trust in scientific experts, trust in policymakers, identification with the Puget Sound region, inspiration drawn from spending time outside in Puget Sound, and attachment to the region. No indicator had a significant negative polychoric correlation with subjective wellbeing.

Table 2: Bivariate correlation values with life satisfaction

	Polychoric $\rho$ (w/ Life satisfaction)
Attachment to Puget Sound region	0.100***
Identification with Puget Sound region	0.139***
Inspired by time spent outdoors	0.107***
Stress reduced by time outdoors	0.092***
Frequency of winter outdoor recreation	-0.007
Frequency of summer outdoor recreation	0.054**
Frequency of wild local resource gathering	0.089***
Ability to access desired wild local resources	0.021
Participation in community activities related to local environment and natural resources	0.075***
Participation in environmental stewardship and restoration activities	0.052**
Time spent with family outdoors	0.038*
Trust in policymakers to protect the environment	0.165***
Trust in scientific experts to protect the environment	0.152***

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

These correlation figures are generally small in magnitude, which is expected. Considering the role that significant life factors such as community, income or health play in human wellbeing, it would be surprising if a factor such as “trust that scientists are doing what is best for the environment” or “identifying with the Puget Sound region” demonstrated a large correlation with life satisfaction. Thus, while bivariate correlation is a good starting point for analyzing the survey results, multivariate analysis provides a more holistic approach that allows us to analyze how key indicators work in concert with demographic variables to mitigate the relationship between indicators and life satisfaction.

### Individual Indicators Correlate into Distinct Factors

While most bivariate correlations between indicators and life satisfaction are small in magnitude, many of the indicators are strongly correlated with one another. This is to be expected, since these indicators address closely related concepts. For instance, one might anticipate that trust in scientific experts to protect the environment is highly correlated with trust in government and public officials to protect the environment. Thus, instead of conducting a multivariate regression

of life satisfaction on all measured variables, we first conducted a factor analysis to better understand the underlying characteristics that these indicators measure. In the subsequent section, we then regress life satisfaction on the latent variables identified by the factor analysis.

We used polychoric factor analysis to suggest common factors based on the variables. Briefly, exploratory factor analysis is a statistical technique used to identify underlying relationships amongst measured variables. In the example from the previous paragraph, for instance, trust in both scientific experts and public officials to protect the environment might be reflective of an underlying characteristic such as confidence in institutions (Bartholomew et al. 2008). The goal of factor analysis then is to represent multivariate data using a smaller number of factors. If two variables are strongly related, then a large portion of their overall variance can be represented using a single factor. The relationship between each individual variable and a given factor is expressed by factor loadings, which essentially reflect the correlation between a given variable and a given factor. Factors themselves are identified based upon eigenvalues, which essentially represent the proportion of overall variance that a given factor explains. Eigenvalues greater than one evidence prominent factors, since this means that a factor explains more variance than any single variable can.

Six factors had significant explanatory value for these data; the individual factor loadings for each are shown in Table 3. Factor loadings can be interpreted similar to correlation; the loading for a given variable on a factor reflects the extent to which that factor accounts for the variable. Essentially, a high loading reflects that a given variable makes a significant contribution to a given factor. Factor 1 (labelled as such because it has the highest eigenvalue) has high loadings for personal attachment to Puget Sound and personal identification with the Puget Sound region, and relatively small loadings for every other variable. We refer to this factor then as “Sense of Place.” We labeled the second factor “Outdoor Activities,” as it shows strong loadings for winter and summer recreation, as well as time spent outside with family. Frequency of wild local resource gathering and ability to access desired quantities of wild local resources appear closely related--as expected--and load strongly on factor 3, the “Resource Access” factor. The final three factors also reveal underlying traits as revealed by pair of variables, namely “Psychological Wellbeing” (inspiration and stress reduction drawn from time spent outside), participation in “Cultural Activities” related to the local environment (cultural events such as farmer’s markets and stewardship actions), and “Good Governance” (trust in local officials and in scientific experts to protect the environment).

Table 3: Factor loadings

Variable	Loadings on Factors					
	Sense of Place	Outdoor Activities	Resource Access	Psychological Wellbeing	Cultural Activities	Good Governance
Trust in policymakers	0.13	0.12	0.09	0.02	0.13	0.55
Trust in experts	0.09	0.08	-0.02	0.12	0.04	0.94
Attachment to Puget Sound	0.96	0.11	0.13	0.16	0.1	0.07
Identify with Puget Sound	0.75	0.14	0.03	0.12	0.09	0.19
Inspired by outdoors	0.18	0.2	0.16	0.94	0.09	0.1
Stress reduction	0.15	0.27	0.17	0.62	0.19	0.08
Winter outdoor	0.12	0.69	0.15	0.08	0.2	0.08
Summer recreation	0.04	0.61	0.18	0.21	0.02	0.11
Resource gathering	0.07	0.22	0.85	0.17	0.15	0.07
Resource access	0.08	0.17	0.8	0.12	0.13	0.03
Family time	0.13	0.67	0.11	0.18	0.24	0.08
Community activities	0.07	0.2	0.12	0.15	0.95	0.12
Stewardship activities	0.14	0.23	0.22	0.1	0.48	0.12

In many cases, these factor loadings reveal relationships that one might have predicted at the outset such as attachment to Puget Sound and identification with Puget Sound. Statistically demonstrating these linkages is significant, however, because it shows how different survey items can inform broader constructs. Specifically, the factor analysis results support the human wellbeing and quality of life Vital Sign groupings suggested to the Puget Sound Partnership.

Table 4 provides a slightly different perspective, showing the weights applied to each factor. Factor weights (also sometimes called factor scores) reveal how individual observations are computed into factor value. Weights are applied to observed data to calculate each respondent's score on every factor. Weights are computed such that each factor score has a mean of zero and a standard deviation of one.

Table 4: Factor analysis weights

Variable	Sense of Place	Outdoor Activities	Resource Access	Psychological Wellbeing	Cultural Activities	Good Governance
Trust in policymakers	-0.01	0.01	0.01	-0.01	-0.01	0.08
Trust in experts	-0.04	-0.07	-0.03	-0.06	-0.09	0.93
Attachment to Puget Sound	1.07	-0.11	0.00	-0.16	-0.02	-0.09
Identify with Puget Sound	0.01	0.04	-0.03	-0.01	-0.01	0.03
Inspired by outdoors	-0.14	-0.12	-0.11	1.15	-0.12	-0.10
Stress reduction	-0.01	0.07	0.00	0.00	-0.01	-0.01
Winter outdoor	-0.02	0.42	-0.05	-0.07	-0.07	-0.02
Summer recreation	-0.02	0.31	-0.03	-0.05	-0.05	-0.01
Resource gathering	-0.07	-0.04	0.69	-0.10	-0.07	0.04
Resource access	-0.03	-0.05	0.38	-0.05	-0.03	0.01
Family time	-0.02	0.40	-0.07	-0.06	-0.06	-0.02
Community activities	-0.07	-0.15	-0.13	-0.03	1.11	-0.03
Stewardship activities	0.00	0.04	0.02	-0.01	-0.01	0.01
Eigenvalue	4.58	0.93	1.02	1.26	1.56	1.12

### Factors Vary by Demographics

Many of the factors demonstrate significant differences across demographic characteristics and subpopulations. Figure 1 shows the distribution of factor values by gender. Males score significantly higher on sense of place, outdoor activities, and good governance, while females score higher on resource access. Gender differences for psychological wellbeing and cultural activities are negligible. The y-axis values for Figures 2, 3, and 4 are factor scores; each bar thus represents the 95% confidence interval for the mean factor score for each demographic subgroup.

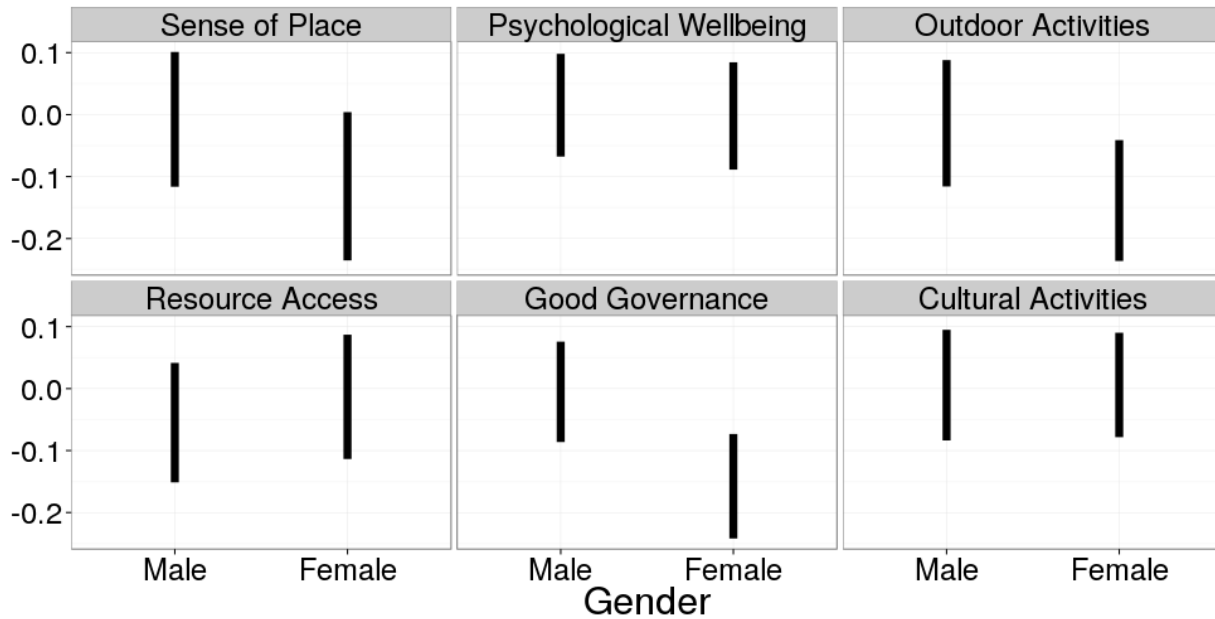


Figure 1: Factor values by gender

Figure 2 explores the factors by urban, suburban, rural populations and unidentifiable populations. Estimates for these unknown individuals (third column in each panel of Figure 2) should fall between the two extremes (since they are a mix of both), which is in fact what we observe in each panel. For most factors, the rural-suburban-urban distinction is negligible. The resource access factor, however, is significantly higher for rural populations and lower for urban populations. While this gap is not unexpected, it is nonetheless interesting that the data reveal such a stark discrepancy. This demonstrates that residential density plays a key role in resource-related indicators, and that managers might consider monitoring strategies that account for these differences.

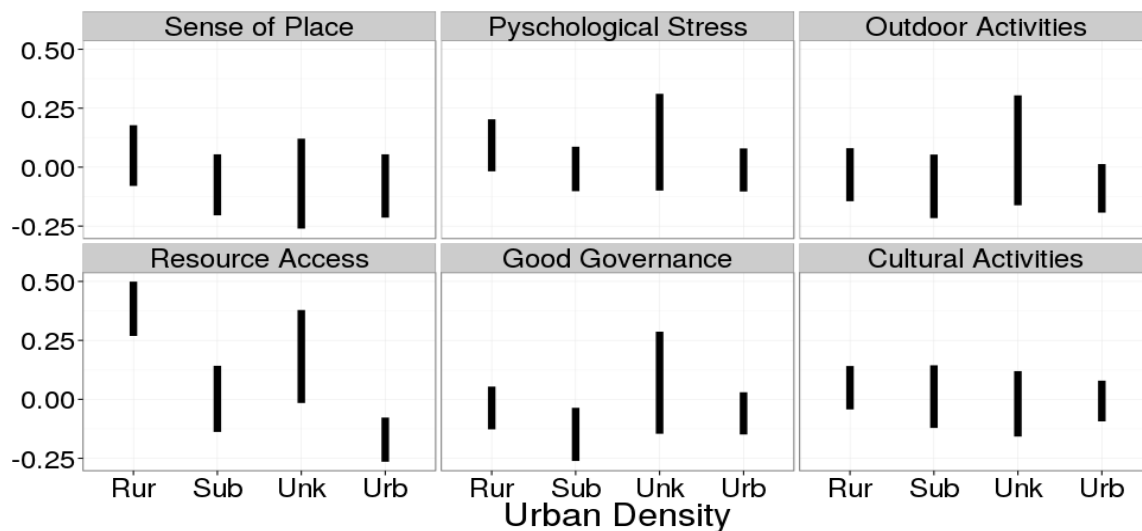


Figure 2: Factor values by residential density

See Appendix IV for maps of how the factors vary by county.

Figure 3 analyzes factor values by age group. The variance is highest for the oldest age bracket, since there are fewer older residents included in the sample. We observed a rather stark difference in sense of place between those in the oldest age bracket (45-54) and all other groups. It is not clear what might be driving this result, but nonetheless this is an issue that merits follow-up. Resource access and Good governance factors show increasing and decreasing (respectively) trends across age groups. Older respondents report that they have better access to natural resources and engage in resource gathering more frequently. Conversely, older residents are less likely to trust institutions. Participation in cultural activities shows a slightly u-shaped curve. This might be explained by younger and older adult residents having more discretionary time and/or resources to participate in such activities relative to middle-aged adults.

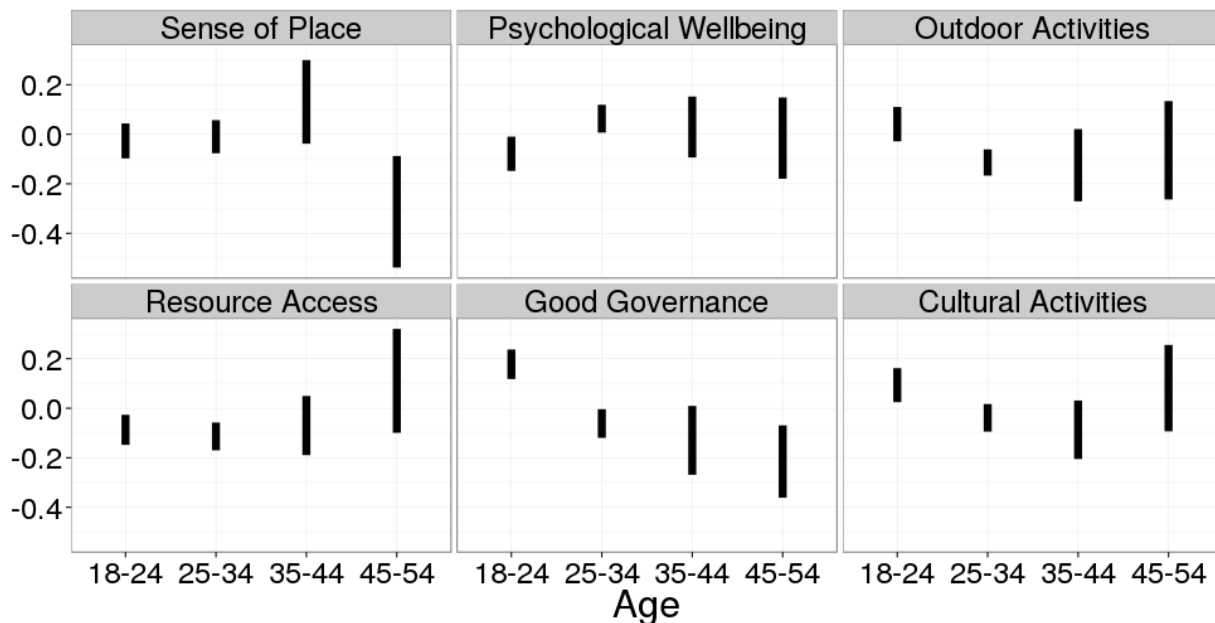


Figure 3: Factor values by age group

Finally, Figure 4 presents factor scores by time lived in the Puget Sound region. Most noticeably, time spent in the Puget Sound region strongly related to Sense of Place, as evidenced by the strong positive trend between time lived in Puget Sound and the resultant factor score. For the other factors there is not a clear relationship between time spent in the Puget Sound region and the factors.

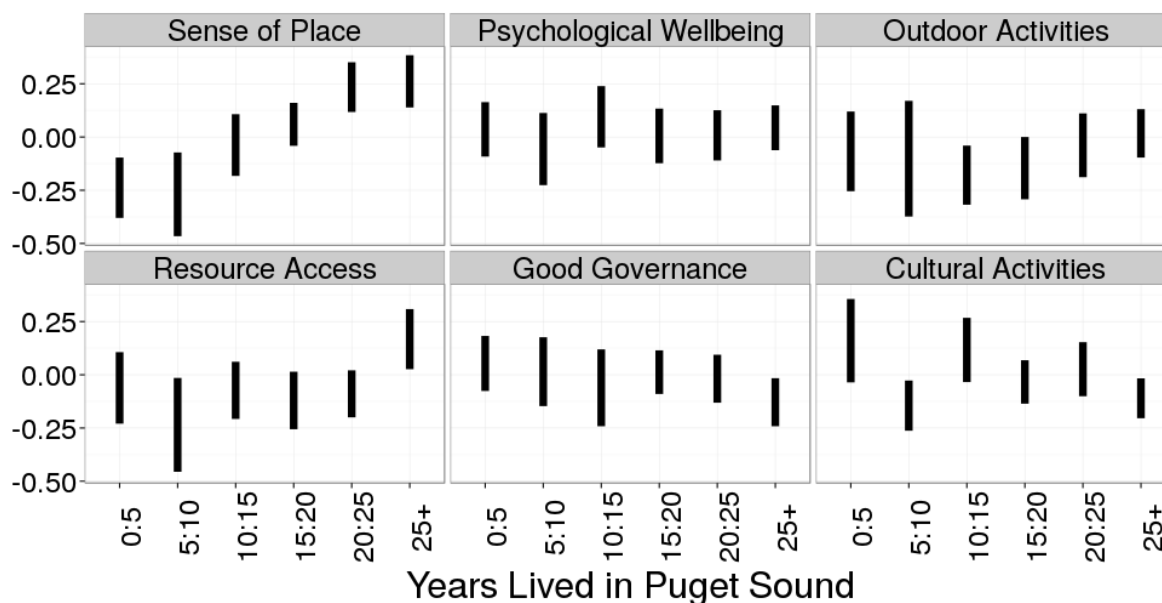


Figure 4: Factor values by years lived in Puget Sound

### Factors Predict Life Satisfaction

Having examined the demographic and geographic variation of the factors, we now proceed to estimate the relationship between each factor and life satisfaction. Unlike in the bivariate polychoric correlations shown in Table 2, this model allows us to control for demographic characteristics, location, and other indicators to isolate the relationship between life satisfaction and each factor.

The life satisfaction variable has a categorical ordinal likert-scale response structure, where the respondent designates whether she is extremely dissatisfied, somewhat dissatisfied, neither dissatisfied nor satisfied, somewhat satisfied, or extremely satisfied with her life in the past year. While it is clear that the rank order of these responses matters, a standard linear regression would be inappropriate since there is not a meaningful quantitative difference between each category. Instead, we estimated an ordered logit regression that estimates the probability of being in a given category versus any lower-ranking category. The other coefficients were then interpreted as in a logit model, where each coefficient refers to an additive change in the log odds. To ease interpretation, we exponentiate these coefficients to produce a multiplicative effect on the odds ratio. Thus, a coefficient greater than one shows a positive effect and a coefficient less than one shows a negative effect.

Parameter estimates where the posterior bounds do not encompass one are shown in boldface; the boldface reflect parameters for which the model shows a strong non-negligible effect (since baseline odds \* 1 = odds) (Table 5). **Of the demographic covariates controlled for in the model, only income demonstrates a strong relationship with life satisfaction.** Net of all other variables, moving up one income bracket increases the odds of reporting strong life satisfaction by 6% to 35%. For the sub-region adjustments, the reference category is the **Clallam County-Jefferson County sub-region. This region has the lowest life satisfaction values on average,**



and thus the adjustments for all other sub-regions shows a strong increase in the odds of a respondent reporting that she is extremely satisfied with her life.

Controlling for demographic characteristics and location, four of the six human wellbeing factors were strong predictors of life satisfaction. Net of all other variables, respondents who report that they have trust in local institutions are 30% to 84% more likely to report that they are extremely satisfied with their life. Frequent participation in community activities related to the natural environment predicts a respondent to be 8% to 68% more likely to report strong life satisfaction. Residents who strongly identify with the Puget Sound region and those who engage in outdoor activities more frequently are similarly more likely to report that they are extremely satisfied with their lives.

**Table 5: Predictors of Life Satisfaction**

<i>Human-environmental wellbeing indicators</i>		
<b>Cultural Activities</b>	<b>1.08</b>	<b>1.68</b>
<b>Good Governance</b>	<b>1.30</b>	<b>1.84</b>
<b>Sense of Place</b>	<b>1.19</b>	<b>1.73</b>
<b>Outdoor Activities</b>	<b>1.06</b>	<b>1.72</b>
Resource Access	0.72	1.07
Psychological Wellbeing	0.92	1.46
<i>Local sub-region</i>		
<b>Island, San Juan</b>	<b>1.52</b>	<b>4.15</b>
<b>King</b>	<b>1.11</b>	<b>2.88</b>
<b>Kitsap</b>	<b>1.67</b>	<b>3.80</b>
<b>Lewis, Mason, Thurston</b>	<b>1.55</b>	<b>4.06</b>
<b>Pierce</b>	<b>1.14</b>	<b>2.41</b>
<b>Snohomish</b>	<b>1.11</b>	<b>2.73</b>
<b>Whatcom, Skagit</b>	<b>1.06</b>	<b>2.78</b>
<i>Demographic covariates</i>		
Puget Sound Years Residence	0.98	1.00
<b>Income</b>	<b>1.06</b>	<b>1.35</b>
Age	0.74	1.08
Male	0.71	1.35
<i>Conditional intercept estimates</i>		
<b>Extremely dissatisfied Somewhat dissatisfied</b>	<b>0.04</b>	<b>0.14</b>
<b>Somewhat dissatisfied Neither satisfied nor dissatisfied</b>	<b>0.29</b>	<b>0.47</b>
<b>Neither satisfied nor dissatisfied Somewhat satisfied</b>	<b>0.47</b>	<b>0.75</b>

## Conclusions and Recommendations

### Validity of Recommended Human Health and Wellbeing Vital Signs

This pilot test shows that the recommended attributes of Cultural Activities, Good Governance, Local Foods (resource access), and Outdoor Activities for the Puget Sound quality of life and human wellbeing Vital Signs are theoretically sound. This means that the responses to the questions we asked to represent these attributes are more correlated to each other than to any other questions, as determined through the factor analysis. The primary contradictions to this are the factors representing Psychological Wellbeing and Sense of Place. Based on the questions we asked to represent these constructs, they are theoretically separate (the questions about identity and attachment correlate more to each other than they do to questions about stress reduction and inspiration). The recommended Sense of Place vital sign, however, includes both sense of place and psychological wellbeing indices. This is not a critical concern, as there is no assumption that Vital Signs be theoretically distinct constructs, or that the indicators within the Vital Signs be theoretically unified.

Although we demonstrated that the recommended Vital Signs are theoretically sound, we only asked a portion of the recommended subjective indicators for each Vital Sign because the pilot study was conducted before completion of the recommendation document. As a result, these same factor analysis methods need to be conducted with the pilot questions that represent all the recommended Vital Sign indicators to test for internal validity. For example, this survey asked questions about trust in government and trust in scientists, yet the recommended Good Governance Index identifies an additional four questions: opportunity to influence decisions, freedom to make decisions, access to education, and representation. To test the validity of these questions in representing the Vital Sign, the same factor analysis methods need to be employed to determine if all questions are actually needed in order to measure the full construct of good governance. In some cases, however, we will not be able to test for internal validity among indicators. For example, while this study demonstrated that subjective resource access questions are a theoretically relevant construct, different from other Vital Signs, we cannot test the validity of the recommended Local Foods Vital Sign because the subjective access measures and the recommended objective measure of Shellfish bed closures are collected at different scales.

### Indicators Predictability of Overall Life Satisfaction

One of our primary questions when initiating this pilot study was whether the stakeholder-identified indicators of human wellbeing related to the natural environment actually correlated to a global measure of subject wellbeing. To test this, we asked every respondent one overall life satisfaction question, and then correlated their responses to the indicator responses. Unsurprising, we found eleven of the thirteen individual indicators to significantly, yet minimally, correlate to overall life satisfaction. This is unsurprising because people had identified these indicators as being important to them. The most robust finding, however, was that, controlling for demographics, four of the statistically identified factor groupings significantly **predicted** life satisfaction responses. This is

important because it suggests that these identified Vital Signs are indeed good proxies for human wellbeing as it relates to the natural environment. It also highlights that if we had limited funding, these four Vital Signs would be priority measures of human wellbeing, with resource access and sense of place indicators being less important.

### Data Collection Tool

A final purpose of this study was to explore the use of an Internet-based data collection tool and the application of a matrix design using several “mini” surveys. The benefit to the mini survey is that it takes significantly less time to complete (usually less than two minutes per respondent) which means we had lower attrition rates and the entire survey process was completed in a short period of time. In this case, we reached a sample size of 4,418 responses in 13 days. The easy, Internet-based nature of this tool also resulted in cost-effectiveness. The cost to launch a survey of 13 questions in a matrix format to 4,418 people was approximately \$10,000. This does not include the time required to develop the survey questions nor the somewhat complex data preparation and analysis steps. Unlike a standard full survey (phone, paper or Internet-based), the matrix design requires imputation of responses to all questions based on a person’s responses to six questions. This must be conducted by an expert in statistical analysis.

In choosing the survey method (Web, phone or paper-based), there are several potential factors to consider. The primary ones include demographic distribution of respondents, response rates, and cost. The ideal response rate is about 30% with demographic distribution closely mirroring the representative sample. Phone-based responses tend to skew toward elderly populations, often have very low response rates (e.g., around 2%), and are about average in cost, depending upon the sample. Web based responses tend to favor younger populations but have better response rates and are often the cheapest alternative. Paper-based surveys have the potential for the most representative distribution and highest response rates, yet they are also the most resource intensive.

This study had a median response rate of 43% and addressed the concerns of demographic representativeness by weighting the data to match the distribution of demographic factors across the Puget Sound. This is a common way to handle skewed data for any tool (phone or Web).

A recent study by Pew also found that actual responses may differ between Web and Phone-based surveys (Keeter 2015). They found three primary trends: 1) People express more negative views of politicians in Web surveys than in phone surveys, 2) People who took phone surveys were more likely to say that minority groups faced “a lot” of discrimination, 3) People are more likely to say they are happy with their family and social life in phone surveys than in Web surveys. All three of these cases represent the social desirability bias: the fact that people try to make themselves and their surroundings sound favorable when interacting with an actual interviewer. This may be a particular concern for political opinion-based survey questions and personal reflections of behaviors and attitudes, such as those measuring the human wellbeing indicators.

The response trends from this study should now be compared to the response trends from the 2015 phone-based General Opinion study to determine how similar questions in the same sample population vary based on the data collection tool. This will help determine which method to use in the future.

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## Appendix I. Survey Questions

The University of Washington would like to learn more about your relationship to the Puget Sound natural environment. Please help us by answering these short questions.

1. Q2: The University of Washington would like to learn about your relationship to the natural environment. How many years have you lived in the Puget Sound region?
- 

2. Q1: In the past year, how satisfied have you been with your life as a whole?

Mark only one oval.

Extremely dissatisfied

☐

Somewhat dissatisfied

☐

Neither satisfied nor dissatisfied

☐

Somewhat satisfied

☐

Extremely satisfied

☐

3. Q3: I am attached to the Puget Sound region.

Mark only one oval.

Strongly disagree

☐

Disagree

☐

Neither agree nor disagree

☐

Agree

☐

Strongly agree

☐

4. Q4: I identify with the Puget Sound region.

Mark only one oval.

Strongly disagree

☐

Disagree

☐

Neither agree or disagree

☐

Agree

☐

Strongly agree

☐

5. Q5: In the past year, how often have you felt inspired when spending time in nature?

Mark only one oval.

Almost never or never

☐

Some of the time (about a third)

☐

About half of the time

Most of the time (about two-thirds)

Almost always or always.

☐

6. Q6: In the past year, how often has spending time in nature helped you reduce stress?

Mark only one oval.

Almost never or never

☐

Some of the time (about a third)

☐

About half of the time

Most of the time (about two-thirds)

Almost always or always.

☐

7. Q7: This past winter, how often did you engage in outdoor recreational activities (such as walking, kayaking, or skiing)?

Mark only one oval.

Rarely or never (less than 1 time per month)

☐

About 1-3 times per month

About 1 time a week

Several times per week (about 3 times a week)

☐

Almost every day (at least 5 times a week)

☐

8. Q8: This past summer, how often did you engage in outdoor recreational activities (such as walking, kayaking, or gardening)?

Mark only one oval.

Rarely or never (less than 1 time per month)

☐

About 1-3 times per month

About 1 time a week

☐

Several times per week (about 3 times a week)

☐

Almost every day (at least 5 times a week)

☐☐☐



9. Q9: In the past year, how often did you gather or hunt wild local resources (such as fish, berries, shellfish, mushrooms, or deer)?

Mark only one oval.

Never

☐

Rarely (once or twice during the season)

☐

Occasionally (several times during the season)

Regularly (most of the season)

Constantly (almost every day during the season)

10. Q10: If you like to gather or hunt wild local resources (such as fish, berries, or deer), how often are you able to access as much as you'd like?

Mark only one oval.

I don't like to gather or hunt

☐

Rarely (less than 30% of the time)

☐

Sometimes

Usually (more than 70% of the time)

☐

11. Q11: In the past year, how often did you participate in a cultural activity celebrating the environment? (such as a salmon ceremony, a harvest festival, or an environmental film festival)

Mark only one oval.

Never

☐

Rarely (at least once or twice)

☐

Occasionally (at least three or four times)

Regularly (at least once a month)

Constantly (at least once a week)

☐

12. Q12: In the past year, how often did you participate in environmental stewardship activities (such as removing invasive plants or environmental monitoring)?

Mark only one oval.

Never

☐

Rarely (at least once or twice)

☐

Occasionally (at least three or four times)

Regularly (at least once per month)

☐

Constantly (at least once per week)

☐☐

13. Q13: In the past year, how often did you spend time outdoors with your close friends or family?

Mark only one oval.

- Rarely or never (less than 1 time per month) ☐ ☐
- About 1-3 times per month ☐ ☐
- About 1 time a week ☐ ☐
- Several times per week (about 3 times a week) ☐ ☐
- Almost every day (at least 5 times a week) ☐ ☐

14. Q14: How much of the time do you think you can trust local policymakers to protect the Puget

Sound?

Mark only one oval.

- Almost never or never ☐ ☐
- Some of the time (about a third) ☐ ☐
- About half of the time ☐ ☐
- Most of the time (about two-thirds) ☐ ☐
- Almost always or always. ☐ ☐

15. Q15: How much of the time do you think you can trust scientific experts to protect the Puget

Sound?

Mark only one oval.

- Almost never or never ☐ ☐
- Some of the time (about a third) ☐ ☐
- About half of the time ☐ ☐
- Most of the time (about two-thirds) ☐ ☐
- Almost always or always. ☐ ☐

## Appendix II: Block Designs

Set Questions

Q1: How satisfied are you with life

Q2: How long have lived in Puget Sound

Designs

Block 1 (N=186):

Winter Activities

Cultural Activities

Local Resource Gathering

Local Resource Access

Block 2 (N=177):

Winter activities

Local Resource Access

Summer Activities

Stewardship Activities

Block 3 (N=195):

Cultural Activities

Trust Scientific Experts

Stewardship Activities

Local Resource Access

Block 4 (N=185):

Trust policymakers

Stress reduction

Attachment

Inspiration

Block 5 (N=182):

Winter activities

Local Resource Access

Attachment

Outdoors with family

Block 6 (N=188):

Inspiration

Attachment

Local Resource Gathering

Stress Reduction

Block 7 (N=177):

Outdoors with Family

Cultural Activities

Trust Scientific Experts

Winter Recreation

Block 8 (N=177):

Attachment

Inspiration

Outdoors with Family

Cultural Activities

Block 9 (N=176):

Local Resource Gathering

Summer Recreation

Stress Reduction

Trust Scientific Experts

Block 10 (N=180):

Outdoors with Family

Cultural Activities

Local Resource Gathering

Stress Reduction

Block 11 (N=184):

Trust Scientific Experts

Stress Reduction

Winter Recreation

Outdoors with Family

Block 12 (N=186):

Trust Scientific Experts

Summer Recreation

Identify

Trust local policymakers

Block 13 (N=182):

Trust Scientific Experts  
Trust Local Policymakers  
Winter Recreation  
Local Resource Access

Block 14 (N=179):

Stress Reduction  
Winter Recreation  
Cultural Activities  
Attachment

Block 15 (N=190):

Identity  
Attachment  
Trust Local Policymakers  
Stewardship Activities

Block 16 (N=179):

Inspiration  
Identity  
Local Resource Gathering  
Attachment

Block 17 (N=178):

Inspired  
Summer Recreation  
Trust Scientific Experts  
Trust Local Policymakers

Block 18 (N=178):

Summer Recreation  
Trust Scientific Experts  
Local Resource Gathering  
Local Resource Access

Block 19 (N=180):

Trust local policymakers  
Summer Recreation  
Outdoors with Family  
Local Resource Access

Block 20 (N=179):

Identity  
Environmental Stewardship  
Stress Reduction  
Cultural Activities

Block 21 (N=183):

Inspiration  
Summer Recreation  
Local Resource Access  
Environmental Stewardship

Block 22 (N=175):

Identity  
Trust Local Policymakers  
Stewardship Activities  
Outdoors with Family

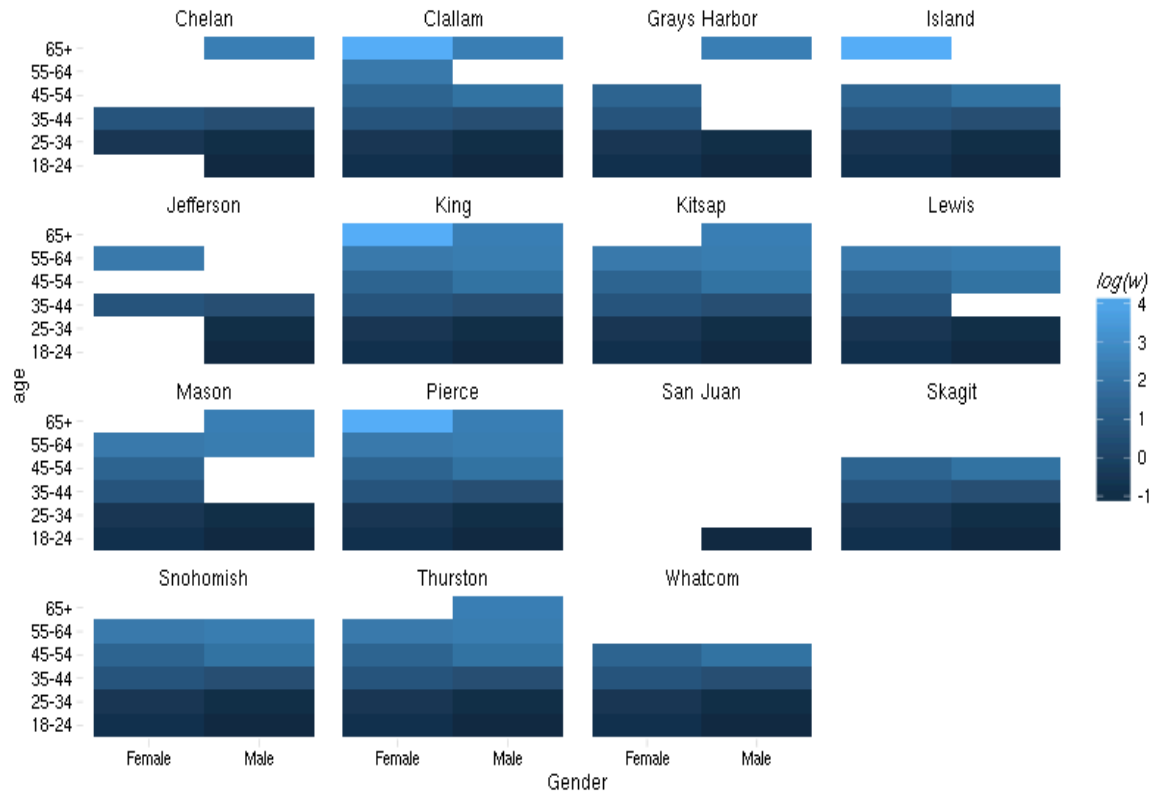
Block 23 (N=193):

Trust local policymakers  
Identity  
Attachment  
Outdoors with Family

Block 24 (N=185):

Identity  
Inspiration  
Local Resource Gathering  
Stewardship Activities

## Appendix III: Sample Properties



## Appendix IV: Responses to Individual Factors by Subregion

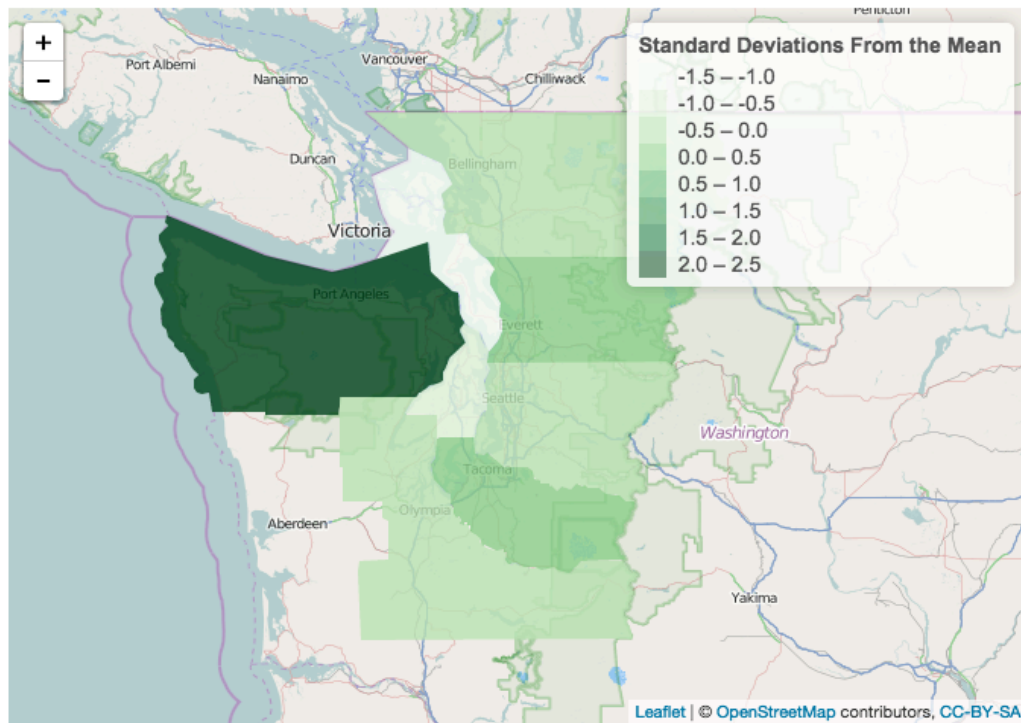


Figure 5. Sense of Place

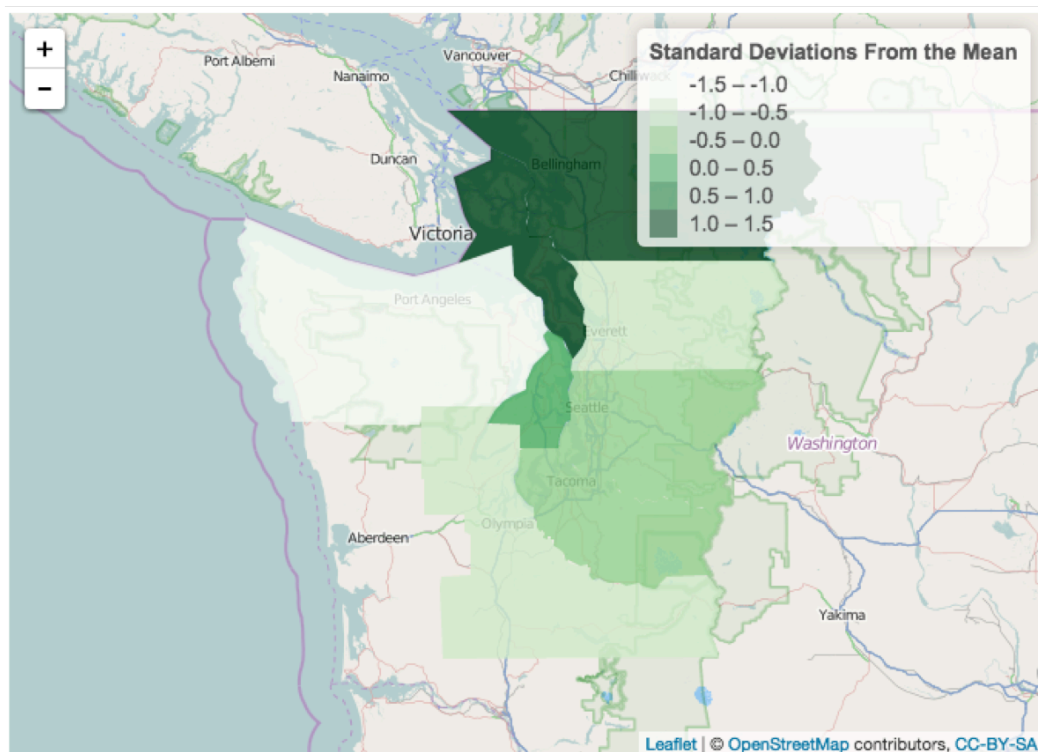


Figure 6. Psychological Wellbeing

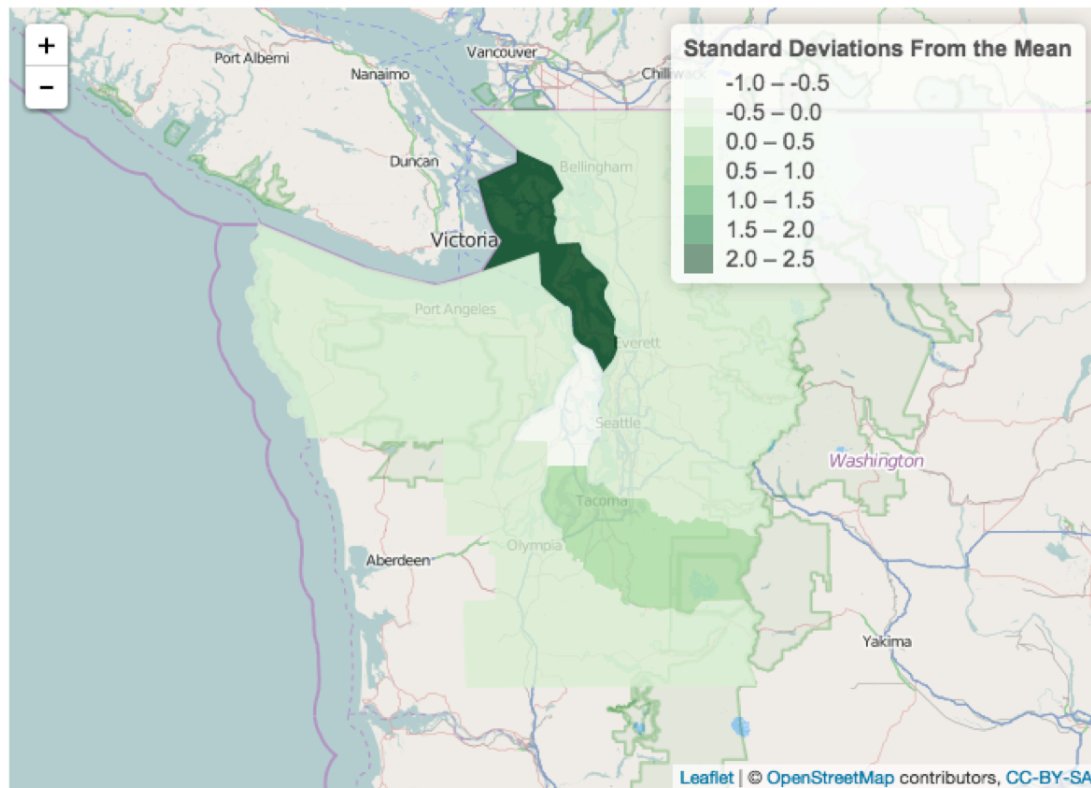


Figure 7. Good Governance.

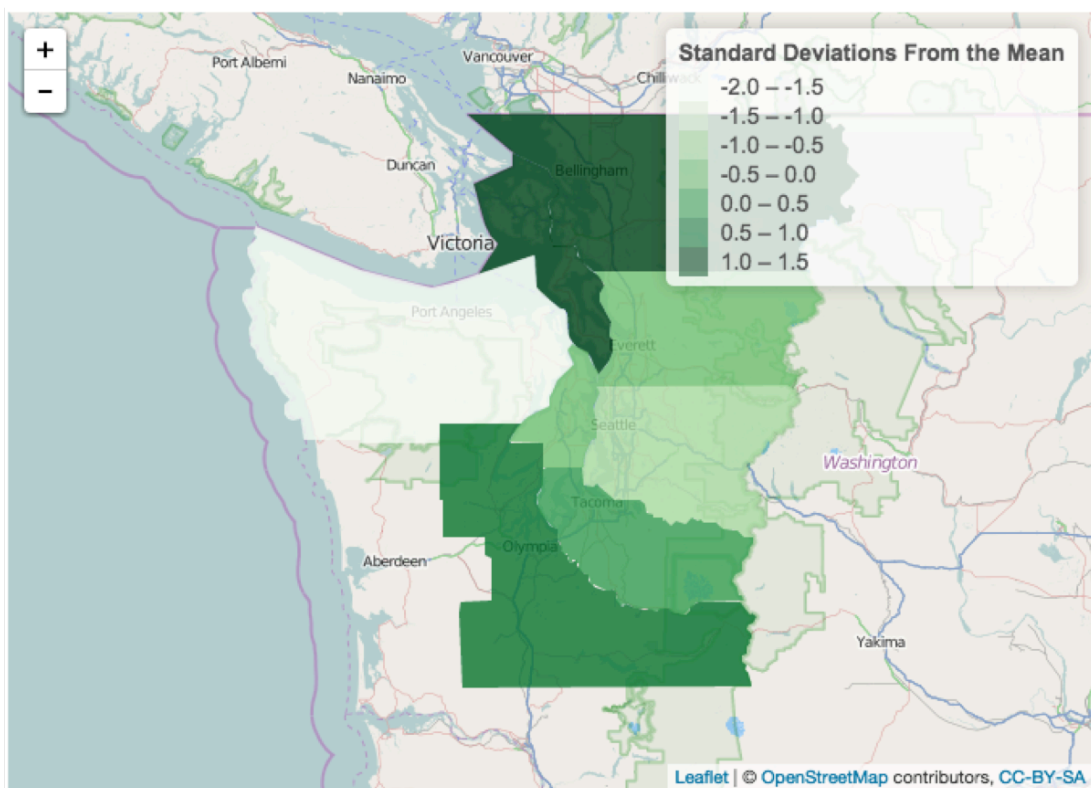


Figure 8. Outdoor Activities.

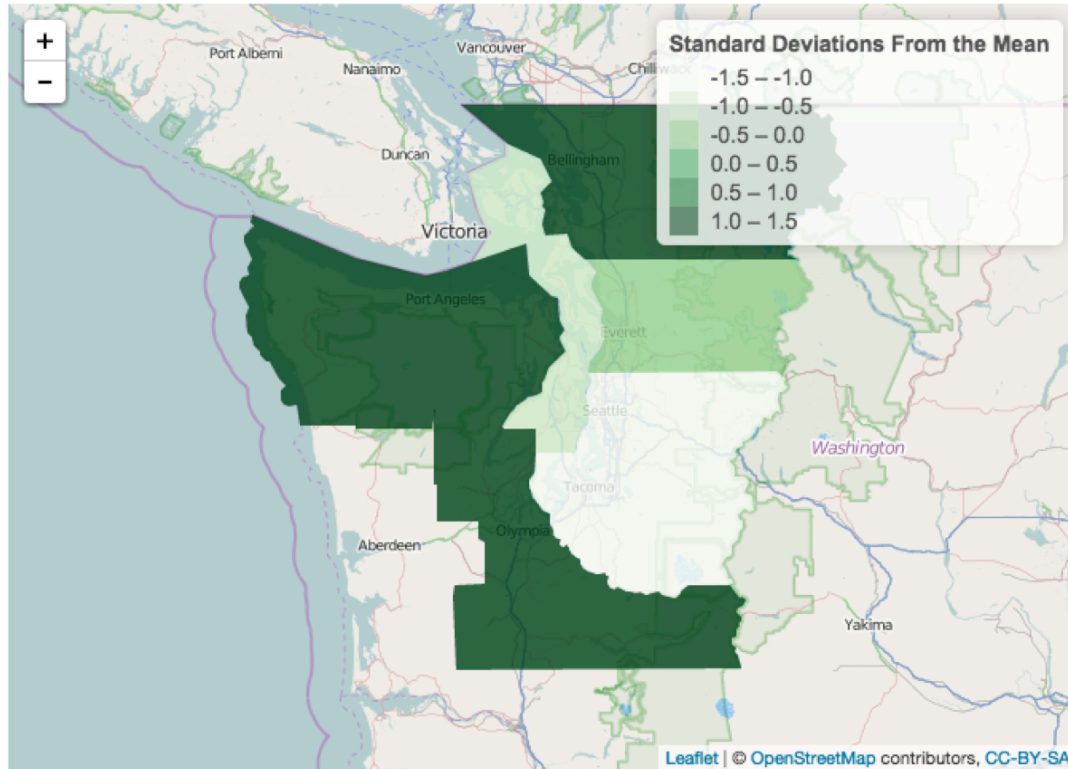


Figure 9. Resource Access.

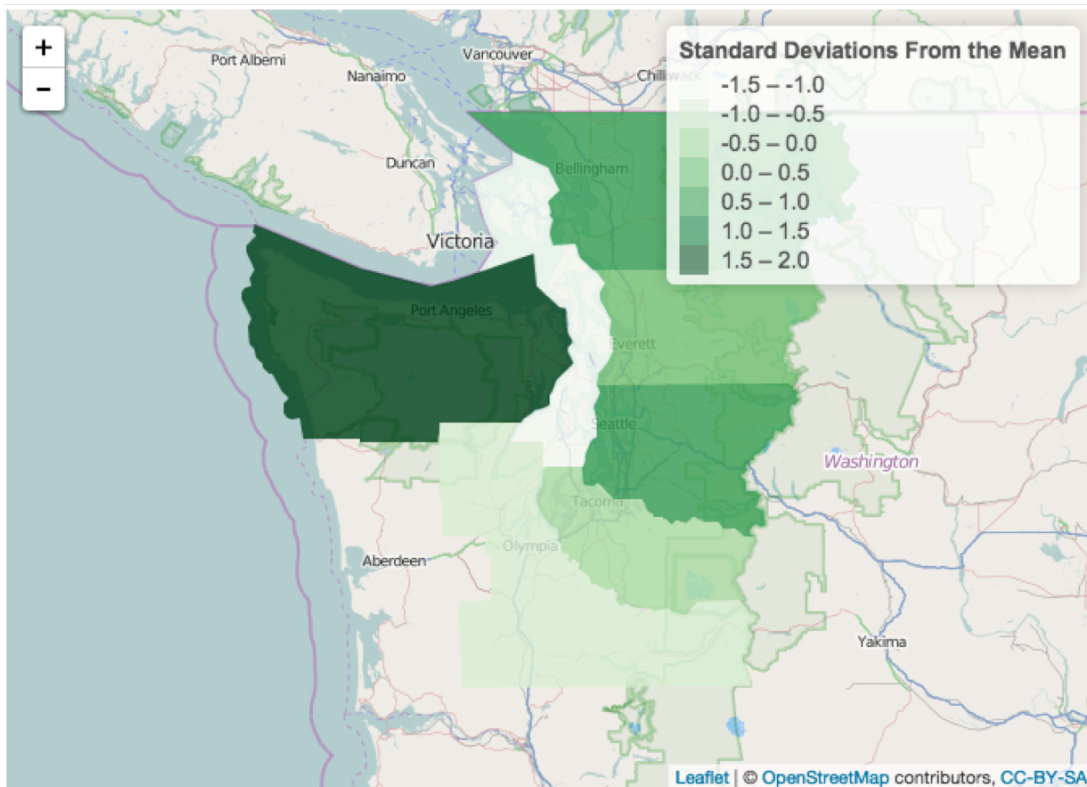


Figure 10. Cultural Activities (Stewardship and Community Activities).