The Disproportionate Effects of Pollution on Indigenous Peoples and How the Trends are Apparent in Pacific Northwestern Tribes

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Abstract

Indigenous communities throughout the United States are among those most impacted by polluting activities, such as mining and oil transportation and other pursuits resulting in adverse environmental and health effects. In addition, these populations are often excluded from environmental justice conversations and routinely exploited for the rich natural resources located on their lands. Polluting activities not only directly harm Indigenous peoples (e.g., polluted food/water sources), these enterprises also undermine cultural and spiritual practices. The present research served to identify national trends of pollution's disproportionate effects on Indigenous tribes and determined if comparable trends existed in Pacific Northwest tribes. Quantitative and qualitative data examined these objectives. The presence of different pollutants was statistically analyzed via Principal Components Analysis (PCA), Correlation Analysis (CA), UPGMA Cluster Analysis, and One-Way Analysis of Variance (ANOVA) to determine if significant differences existed among western Pacific Northwest and intermountain Pacific Northwest tribal lands. Established literature noted pollution increased consistent with the number of minorities in a locality, particularly in low and middle-income areas. Indigenous communities are of special concern, because although these communities represent only 5% of the global population, they comprise >15% of the world's extremely poor. Research suggested this disparity was due to Native colonization and exclusion, leading to the establishment of polluting activities (e.g., mines, oil pipelines, logging, sewage waste, and agriculture, among others) on sovereign lands without free, prior, and informed consent (FPIC). Furthermore, qualitative sources were analyzed to assess the unique challenges that pollutants impose on Indigenous tribes. The present study hypothesized Pacific Northwest tribes experienced similar harmful polluting activities and struggled against polluted food and water sources. It was further hypothesized Pacific Northwest tribes similarly

struggled against violation of treaty rights and exclusion from decision-making processes as do other U.S. tribes. The results of this study showed western and intermountain Pacific Northwest tribes experienced a multitude of pollutant sources, such as mining wastes, pesticides, heavy metals, etc., which showed widespread and unique impacts for their lands and culture (e.g., salmon run disruptions, spiritual impacts, adverse health effects, etc.).

Keywords

Environmental Justice; Indigenous/Native Americans; Pacific-Northwest Tribes; Pollution

Introduction

A History of Native Advocacy for Environmental Justice

The United States has a long history of oppressing and disenfranchising marginalized communities, including, but not limited to, voter suppression in communities of color, redlining, systemic racism, and income inequality (Solomon et al. 2019). The environmental justice movement is one course of action marginalized individuals pursue to remedy disenfranchisement. According to the United States Environmental Protection Agency (EPA), environmental justice refers to the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (United States Environmental Protection Agency 2021). The environmental justice movement gained traction in the 1980s, but Native American communities were largely excluded from environmental justice conversations until 1991, when the People of Color Environmental Leadership Summit was held by the Commission for Racial Justice (Gilio-Whitaker 2020). Their preamble states: "We, the people of color...begin to build a national and international movement of all peoples of color to fight the destruction and taking of our lands and communities, do hereby re-establish our spiritual interdependence to the sacredness of Mother Earth...to secure our political, economic, and cultural liberation that has been denied for over 500 years of colonization and oppression…," (Principles of Environmental Justice 1996, para. 1). Gilio-Whitaker (2020) suggested this wording provided a more inclusive platform for Indigenous advocacy and environmental justice.

In subsequent years, Native Americans have advocated for their environmental liberation. For example, the “water protectors" of the Standing Rock Sioux Tribe and others protested on their behalf to battle the Energy Transfer Partners and expressed their dissent towards the Dakota Access Pipeline (DAPL) in 2014 (Gilio- Whitaker 2020; Brady 2018). Although the movement (termed #NoDAPL) seemingly fizzled under the Trump administration’s reversal of President Obama’s decision to halt construction of a section of the pipeline, the Standing Rock Sioux Tribe and their supporters were recognized for several victories. More than 300 tribal nations stood together in solidarity with the Standing Rock water protectors and the movement was acknowledged as the most significant display of Indigenous protest for environmental justice (Gilio-Whitaker 2020). Another example of Native advocacy for environmental justice is the current call for President Biden to halt the Line Three oil pipeline’s expansion into Minnesota and associated mining projects (Perry 2021). If approved and expanded, the pipeline will pass under the Mississippi River and potentially pollute the source of drinking water for 68 million Americans. These are just a few examples of Indigenous advocacy for environmental justice, but a long fight remains.

National Trends of Pollution Disproportionately Effecting Indigenous Peoples

Despite progress within the environmental justice movement, spurred by their inclusion at the People of Color Environmental Leadership Summit, Native Americans remain among the worst-affected populations in being disproportionately impacted by pollution (Gilio-Whitaker 2020). Zou et al. (2014) showed racial minorities, including Native Americans were more likely to be exposed to benzene air pollution than white communities. The Commission of Racial Justice found nearly half of all Native Americans/Pacific Islanders live in areas with uncontrolled toxic waste sites (Toxic Wastes and Race 1987). Twenty years following the

report's release, Bullard et al. (2008) showed racial minorities, including Native Americans, were still disproportionately located around toxic waste sites, but remained even more concentrated around toxic areas. According to a comprehensive review by Fernández-Llamazares et al. (2019), over 600,000 Native Americans in the U.S. live within 10 km of an abandoned mine, notably increasing their risk of exposure to pollutants. This study also found numerous pollutant-introducing practices disproportionately affecting Indigenous peoples worldwide. These practices included oil/gas extraction and development, mineral extraction, toxic waste dumping, industrial development, agrochemical contamination, radioactive contamination, and other polluting operations.

Studies showed tribal communities were often attractive targets for pollutant-introducing pursuits because the lands were sparsely populated and rich in natural resources (Garnett et al. 2018; Finer et al. 2008). Furthermore, the infrastructures that introduced pollutants into Native lands (e.g., into their food and water supplies, air) were often established in the absence of free, prior, and informed consent (FPIC) or appropriate safeguards. Portalewska (2012) reported FPIC was the standard by which Indigenous peoples declared their rights to make decisions that influenced their communities. However, these standards were often ignored, or Indigenous communities were manipulated by "tribal councils" that were exploited to bypass Indigenous opposition (Taylor 2014). Similarly, Lewis et al. (2017) indicated violations of treaty rights, slack policies, and the absence of appropriate infrastructure and research resulted in sustained exposure to mining pollutants, creating environmental health disparities in Native communities. These treaties established between various tribes and the U.S. government were meant to recognize each tribe's ability to self-govern and provide them with lands over which they had sovereignty. However, rights the government established by these treaties diminished as the

government identified various mineral resources on tribal lands. This disregard for treaty rights along with the absence of appropriate infrastructure, policy, research, and oversight from governmental and private sectors left Native American communities to absorb the waste of over 160,000 abandoned mines located on their lands (Lewis et al. 2017). These mines and other pollution sources have created an abundance of adverse environmental, health, and cultural impacts for Native American Tribes.

Impacts of Pollution on Indigenous Peoples

Pollution results in a wide array of adverse effects on Indigenous communities, ranging from health and environmental impacts to stripping away cultural ties to the land, water, and wildlife. Fernández-Llamazares et al. (2019) reviewed a variety of these unfavorable environmental impacts, including water system pollution poisoning food (e.g., salmon) and water sources. Pollution not only directly harms Indigenous people, but it also harms the wildlife physiology of the region, causing declines in wildlife populations. For example, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2016) found due to increased exposure to pollutants, such as pesticides, native pollinator populations were in decline, disrupting the food systems upon which Indigenous communities are heavily reliant. Aquatic wildlife was similarly exposed to pollutants, in this case increased levels of plastic. In fact, it is estimated 99% of all seabirds, including those central to many Indigenous diets, will have ingested plastic at some point by 2050 (Wilcox et al. 2016). The report also indicated other aquatic species, such as freshwater crabs and turtles, were subject to a similarly devastating fate with rising mercury (Hg) and lead (Pb) pollution levels.

Health impacts to Indigenous people are primarily associated with ingesting polluted water and food. In fact, Indigenous communities are more vulnerable to this type of pollution

than non-Indigenous groups, due to some tribal customs' frequent use of animal parts (e.g., fatty tissues in marine mammals), which are more susceptible to storing organic pollutants, such as organochlorines and polycyclic aromatic hydrocarbons (Fernández-Llamazares et al. 2019). Exposure to these types of organic pollutants was implicated in increased risk of developing certain diseases, including diabetes, immune system issues and infections, hypertension, cancer, and kidney disease, among others. Additionally, Indigenous people suffer mental health impacts due to the pollution levels in their communities. For example, Palinkas (1993) reported oil spills were associated with psychological disorders, including PTSD and Generalized Anxiety Disorder (GAD) and increased worry regarding pollution was associated with higher levels of anxiety and fear. Fernández-Llamazares et al. (2019) found wildlife declined due to environmental pollution, which contributed to Indigenous communities' increased use of grocery store foods. These foods are expensive and nutrient-poor, and the physical activity typically associated with hunting and fishing was therefore notably reduced (Hoover 2013). This inadequate diet and lack of physical activity often leads to increased risk of malnutrition, which can contribute to chronic illness and stress. Finally, Indigenous communities were forced to stray away from their traditional means of medication due to an increased fear surrounding the contamination of local resources (Arquette et al. 2002).

Pollution has substantial impacts on the individual cultures of Native communities. For example, contamination of local plant species restricts a tribe's ability to harvest these species for culturally significant activities (e.g., certain tribal ceremonies, traditional medicine, basket weaving) (Arquette et al. 2002). Furthermore, pollution severs a tribe's ties to the land and their culture by threatening traditional practices. For instance, many Indigenous tribes associate hunting or gathering wild foods with important community roles (e.g., language preservation).

The Mohawk Nation in particular described degradation of their spoken language and culture surrounding these activities because they abandoned cultural practices due to fear of pollution exposure (Hoover et al. 2012). Pollution also impacts the spiritual wellbeing of Indigenous people by contaminating what are considered divine resources (i.e., water). In many Native cultures, water is viewed as the "lifeblood of Mother Earth" and must be protected from pollutants. Some Native tribes even require their members only drink/use water free from contamination (Tipa and Teirney 2006). An example was observed in a 2005 lawsuit between Arizona's Snowbowl ski resort and the Navajo and Hopi tribes that reside in the area. The resort proposed making snow from reclaimed sewage and spreading it on the San Francisco Peaks Mountain ("Dook'o'oos liid" to the Navajo and "Nuvatukya'ovi" to the Hopi), but the Navajo and Hopi people argued this act would undermine their beliefs and practices that rely on the mountain's purity ("The Arizona Snowbowl" 2013). Obviously, there are apparent trends in the disproportionality of Native experiences with pollution versus those of other populations. The exact effects of certain pollutants vary by tribe and region. This study served to highlight the specific environmental racism struggles experienced by Indigenous tribes in the Pacific Northwest region of the United States.

Research Hypotheses

I tested the following Null Hypotheses (H_o) in this study:

H_{o1}: Indigenous people (Native Americans) in the Pacific Northwest experience a multitude of pollutant-introducing activities on their sovereign lands.

H_{o2}: Pacific Northwest tribes, e.g., Nez Perce, Coeur d'Alene, Blackfeet, Crow, etc., experience disproportionate cultural impacts due to pollution.

Materials and Methods

A literature review was conducted to examine the relationships between and among the national trends of pollution's disproportionate effects on Indigenous communities and how the trends manifest in Pacific Northwest tribes. Primary peer-reviewed journal articles, theses, dissertations, books, book chapters, news articles, and press releases were included in the search. The following databases and search terms were employed: https://scholar.google.com/, EBSCOhost, and PubMed, etc., using terms such as "Indigenous pollution," "Indigenous environmental racism," "effects of pollution on Indigenous people," "environmental pollution," "environmental health disparities," etc. The following analyses were performed to determine the presence of environmental pollutants in certain geographical areas, as well as the adverse effects on Indigenous peoples: Analysis of Variance (ANOVA), Principal Components Analysis (PCA), Pearson's Correlation Analysis (CA), and UPGMA (Unweighted Pair Group Method with Arithmetic Mean) Cluster Analysis. The following variables were used in the analysis: Native tribe; sovereign land location; pollutant(s) type(s); pollutant location, e.g., food, water, ground, air; health effect(s), physical and mental; effect on Indigenous tradition/spirituality. The software PAST was used to conduct the above statistical analyses (Hammer et al. 2001). A One-Way ANOVA was employed to determine whether statistical differences existed between means in the data set, as well as to describe some basic, univariate statistics. ANOVAs combine variance between data sets, differences between means, and sample size to produce an *F*-value that can be further analyzed to determine the probability of statistically significant results (Qualtrics 2022). PCA was performed to reduce the dimensionality of the larger dataset while preserving relevant statistical information, such as correlations among data points (Jolliffe and Cadima 2016). First, a scree plot determines whether a PCA is compatible with the data set. Essentially, if most of the

variation in a data set can be captured within the first three principal components, a PCA is a suitable statistical tool. Principal Component 1 (PC1) represents the maximum variability between the data with minimum error and each subsequent PC (PC2 and PC3 in the analysis) represents a slightly lesser degree of variation. A biplot (PCA loading plot + PCA score plot) is constructed to display clusters of samples based on their similarity (obtained from PCA score plot) and how strongly each characteristic influences a certain PC (obtained from PCA loading plot) (Team 2018). Each tribe represented a single point in the biplot, and each variable was represented by a vector. Data points clustered around a particular vector are likely influenced by the corresponding variable; the further the vector is from the origin, the stronger the relationship. Further, vectors that create angles of less than 90 degrees are likely to be positively correlated. Conversely, vectors that form angles larger than 90 degrees are likely to be negatively correlated with one another and vectors creating angles of 90 degrees are unlikely to be correlated. The CA provided a Pearson's correlation coefficient (*r*) that determined the strength and direction of any relationship found in the data (Boston University School of Public Health 2013). Finally, the UPGMA Cluster Analysis is a distance analysis method that clusters tribes together based on similar relationships among the variables (Weiß and Göker 2011). These clusters should be similar to those provided by the PCA biplots, and therefore, should show consistency among the data. The strength of the relationship between a cluster is signified by the distance a node is away from the axis – i.e., the closer the node, the stronger the relationship. All resources used in this study will be sourced from previously conducted research in the primary literature or primary/secondary accounts. Interpretive analysis of qualitative data was performed regarding any regional and national environmental effects on Indigenous communities. Qualitative measures such as press releases, interviews, anecdotes, and lawsuits, among others, were

interpreted to examine the history of pollution's disproportionate effects on Native U.S. tribes. Qualitative sources were further analyzed in terms of its social relevance (e.g., how Native inclusion at the People of Color Environmental Leadership Summit launched a more accessible platform for Indigenous advocacy for environmental justice). Furthermore, primary accounts from Pacific Northwestern tribes (e.g., the Nez Perce tribe of North-Central Idaho) were gathered to juxtapose national trends of pollution with the struggles of local tribes. These methods of analysis are customary for the field of environmental ethics.

Results

The following contaminants were identified among Pacific Northwest tribes: bacteria, heavy metals (uranium, stibnite, antimony, arsenic, cadmium, copper, lead, mercury, and zinc), oil drilling/oil spills, logging/paper mills, mining, industrial pollution, agricultural pollution, toxic compounds (e.g., PCBs, rubber), nonpoint (i.e., several possible pollutants), pesticides, and waste/sewage.

Univariate statistics are summarized in Table 1. One-Way ANOVA showed significant differences among variables and tribes ($P < 3.031 \times 10^{-15}$). The *a priori* significance level was $P < 0.05$.

A scree plot of the original data set showed most of the variability in the data was captured in the first three Principal Components (PCs) (Fig. 1). The PCA provided two correlation biplots – PC1xPC2 and PC1xPC3 (Figs. 2 and 3). Results were consistent between the two plots (i.e., tribes were similarly clustered in both). While no distinct environmental pollutants were identified by state, some tribes distributed in the same geographic regions experienced similar types of pollutant impacts. For example, the Fort Belknap Assiniboine and Gros Ventre, Kalispel, and Port Gamble S'Klallam tribes were heavily impacted by air pollution,

due to mining and logging pollutants present on their lands. Additionally, PC1xPC2 biplot showed clustering of many tribes around each of the environmental impacts (i.e., mining wastes, water, land, salmon runs, spiritual/cultural impacts, air, food, and health), located near the center of the plot. In other words, while a variety of pollutants affect Pacific Northwest tribes, many of the tribes shared similar negative impacts.

Pearson Correlation Analysis ($n = 34$) revealed a number of statistically significant relationships among the data (Table 2). The *a priori* significance level was $P < 0.05$. Correlations among state and GPS variables were ignored due to lack of relevance to the larger analysis and health impacts had a perfect correlation with every other variable ($r = 1$). Strong positive correlations were observed between water pollution and spiritual/cultural impacts ($r = 0.84$), air pollution and salmon run disturbances ($r = 0.91$), air pollution and spiritual/cultural impacts ($r = 0.91$), and food impacts and air pollution ($r = 0.79$). Moderate positive correlations existed between salmon run disturbances and food impacts ($r = 0.51$), water pollution and salmon runs, air pollution and water pollution ($r = 0.43$), air pollution and land pollution ($r = 0.55$), food impacts and water pollution ($r = 0.43$), mining wastes and salmon runs ($r = 0.41$), mining wastes and water pollution ($r = 0.48$), and mining wastes and land pollution ($r = 0.41$). Surprisingly, a moderate negative correlation existed between food impacts and land pollution ($r = -0.42$), though this might be due to fish being a large source of food for many of the tribes analyzed.

The UPGMA cluster analysis provided results consistent with those of the PCA (Fig. 5). For example, the Crow and Yakima Nations share a node with an approximate distance of 3.0 in the UPGMA analysis and are similarly clustered in the PC1xPC2 biplot (Fig. 2). This indicated both tribes experienced similar pollutant impacts – in this case, water and land pollution. A

similar example includes the Klamath and Shoshone-Bannock tribes. The two tribes share a node with an approximate distance of 4.5 in the UPGMA cluster analysis and are similarly clustered in the PCA. These two tribes experienced water and food pollution, as well as spiritual/cultural impacts. Other tribes were comparatively clustered across the two analyses and thereby increased confidence in these results.

Discussion

The PCA functioned to summarize the larger data set into concise and readable plots. Additionally, the two biplots, PC1xPC2 and PC1xPC3, showed similar clusters of tribes around the same variables, with few exceptions. This is to be expected – had the two biplots differed significantly, the validity of the data would be questionable. UPGMA Cluster Analysis further supported the results provided by PCA.

CA provided valuable insights into how different pollutants interacted with various environmental and health impacts experienced by the tribes. Tribes experiencing interruptions in salmon run patterns were likely to also experience food disruptions. Similarly, food disruptions were correlated with negative spiritual/cultural impacts – as evident in the Mohawk Nation's degradation of cultural practices and language surrounding food hunting and gathering activities. The results generated by CA were consistent with what was expected from the study.

The results revealed by these various statistical methods were consistent across each test. In other words, Indigenous tribes in the Pacific Northwest experience a multitude of pollutant types and impacts. Furthermore, the statistical results of the present study supported both research hypotheses.

Qualitative analysis was essential in identifying pollutant sources and impacts among each of the Pacific Northwest tribes. Secondary sources, such as press releases, news articles, and anecdotes provided especially valuable insights into the cultural and spiritual consequences pollution has on Indigenous communities. For example, the Coeur d'Alene tribe described Lake Coeur d'Alene as a place of bounty and spiritual sustenance that was stripped by those who sought out the lake and surrounding land for materials to sell and the 20th century need for electricity – i.e., the construction of hydroelectric dams ("Challenges – Lake Management" n.d.). Indeed, while the environmental impacts of pollution may affect differing racial groups uniformly (e.g., how lowered air quality due to air-polluting activities such as logging may affect all people in an area, regardless of racial identity), spiritual and cultural impacts were often unique to Indigenous tribes. For instance, oil and gas companies such as Solenex LLC, have routinely disregarded FPIC when leasing the Badger Two-Medicine Region of Glacier National Park in Montana (Moms Clean Air Force 2016). While visitors to the park respect the grandeur and scenery of the land, and would likely lament its degradation, the Badger-Two Medicine region represents an area of great spiritual and cultural significance to the Blackfeet Nation. The Blackfeet people have long relied on the area for hunting, fishing, and performing sacred ceremonies, all of which were forgotten when the land was originally leased beginning in the 1980s (Moms Clean Air Force 2016). This violation of treaty rights and informed consent, as well as the spiritual/cultural implications of drilling the land, are unique to the Blackfeet people. In other words, the degradation of the region does not bear the same consequences for white or other minority individuals/communities.

Similarly, Indigenous peoples experienced disproportionate disruptions to food sources. For example, tribes who relied on traditional food sources, such as Chinook salmon, experienced

disruptions to the quantity and quality (i.e., health) of salmon runs. The following tribes reported salmon run disruptions: Colville, Coquille, Lummi, Makah, Muckleshoot, Nez Perce, Nooksack, Puyallup, Quileute, Salish, Skokomish, Stillaguamish, Swinomish, Tulalip, and Upper Skagit. Still more tribes reported additional disruptions to various other aspects of their food systems, e.g., the Confederated Tribes of Umatilla reported that toxic waste from the Hanford Nuclear Site contaminated their "natural" food sources (Schure et al. 2013). Traditional and organic food systems have long been integral to an Indigenous way of life in ways that white communities, especially, often do not experience.

The experiences reported by Pacific Northwest tribes, especially those regarding spiritual and cultural degradation due to pollution, were comparable to those reported by other tribes across the United States. Moreover, Pacific Northwest tribes routinely cited violation of treaty rights (as with the Blackfeet Nation and Solenex LLC) and a disregard for FPIC when polluting activities were established on their sovereign lands. Qualitative analysis highlights how future discussions about environmental racism and justice should be conducted with respect to Indigenous experiences and struggles. Further, these results bolster those provided by the quantitative analysis.

Little empirical research exists regarding the difference in rates of pollution found in Pacific Northwest Indigenous communities compared with those found in communities of color in similar regions and is therefore a limitation of the present study. Additionally, this study excluded tribes from the analysis based on the following criteria: if the tribe cited "climate change" instead of a specific pollutant source, if the pollutant source had been largely eradicated by the tribe and/or local community, if the tribe actively engaged in a polluting activity (e.g., mining), even if they were financially coerced to do so, or if the tribe experienced pollution due

to wildfires. Future research should address each of these issues in greater detail and should also consider how Indigenous communities are leading efforts to clean up pollutants on their lands and surrounding areas. Finally, the issue of climate change is particularly interesting as it may impact Indigenous communities at greater rates than white communities and may have even more widespread consequences.

Conclusion

Native Americans in the United States have a history of being disproportionately affected by environmental pollution and its impacts (e.g., water, soil, air, Native food species/sources, among others). Native sovereign lands are often exploited by the government due to their rich natural resources, low Native population density, and increased unemployment rates. Additionally, Indigenous communities often outwardly oppose pollutant-introducing activities, such as mining, but are often ignored. It is important to elucidate how these activities impact tribes across the U.S., but also how they affect tribes in the Northwest Intermountain region. This research served to expose some of these impacts and illuminate how Pacific Northwest tribes are not exempt from national trends.

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Figure 1

One-way ANOVA | Effects | Tukey's pairwise | Residuals | Kruskal-Wallis | Mann-Whitney pairwise | Dunn's

Test for equal means

	Sum of sqrs	df	Mean square	*F*	*p* (same)
Between groups:	68680.7	12	5723.39	2229	0
Within groups:	1134.68	442	2.56716		**Permutation *p* (n=99999)**
Total:	69815.3	454			1E-05

Components of variance (only for random effects):
Var(group): 163.452 **Var(error):** 2.56716 **ICC:** 0.984537

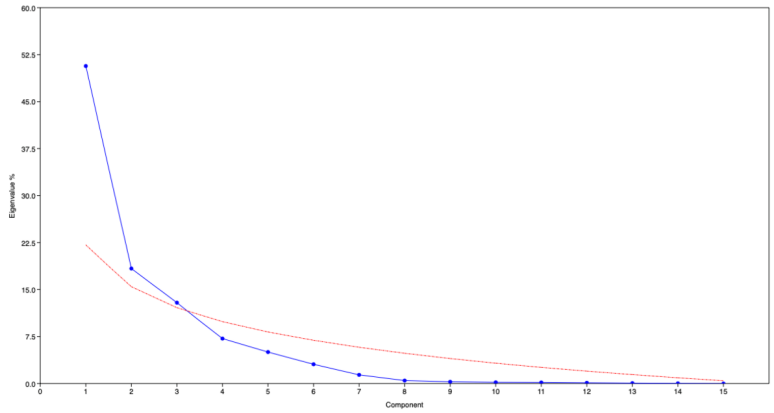
***omega*2:** 0.9833

Levene´s test for homogeneity of variance, from means *p* (same): 3.067E-34
Levene´s test, from medians *p* (same): 3.031E-15

Welch *F* test in the case of unequal variances: *F*=767.3, df=170, *p*=3.557E-141

Univariate statistics as described by One-Way ANOVA. Levene's test, from medians ($p < 3.031x10^{-15}$).

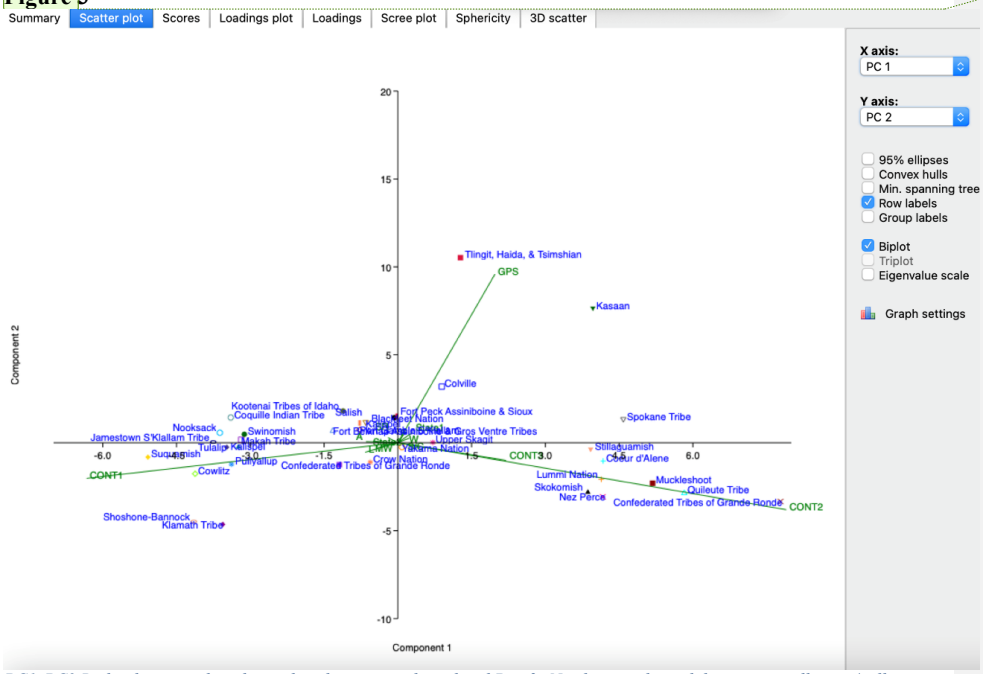
Figure 2



PCA Scree Plot depicting the variability of the larger data set. Most variation falls within the first three principal components.

Figure 3

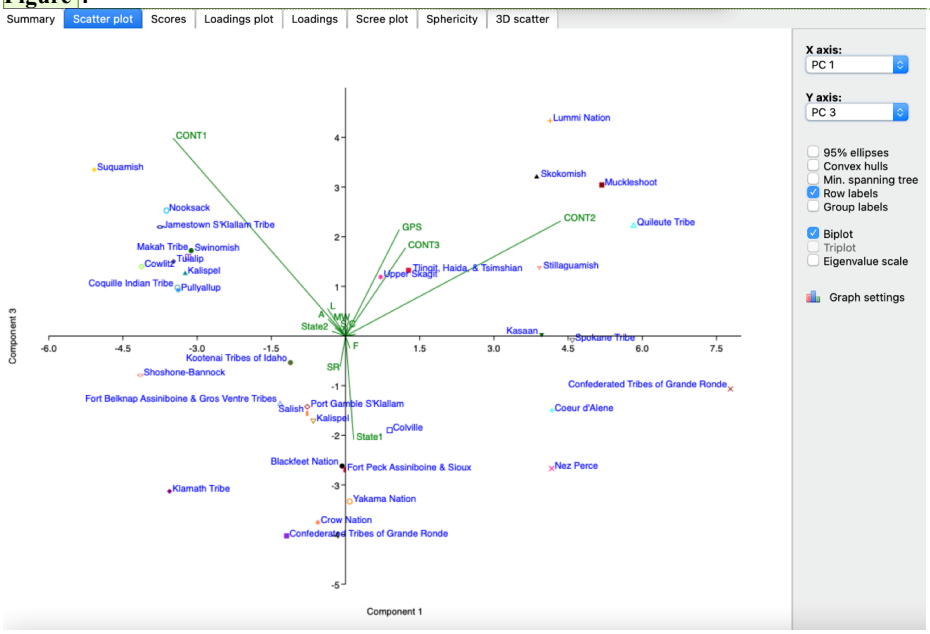
Commented [BSN1]: Swap with correctly labeled biplot



PC1xPC2 Biplot depicting the relationships between each analyzed Pacific Northwest tribe and the various pollutants/pollutant impacts

Figure 4

Commented [BSN2]: Swap with correctly labeled biplot



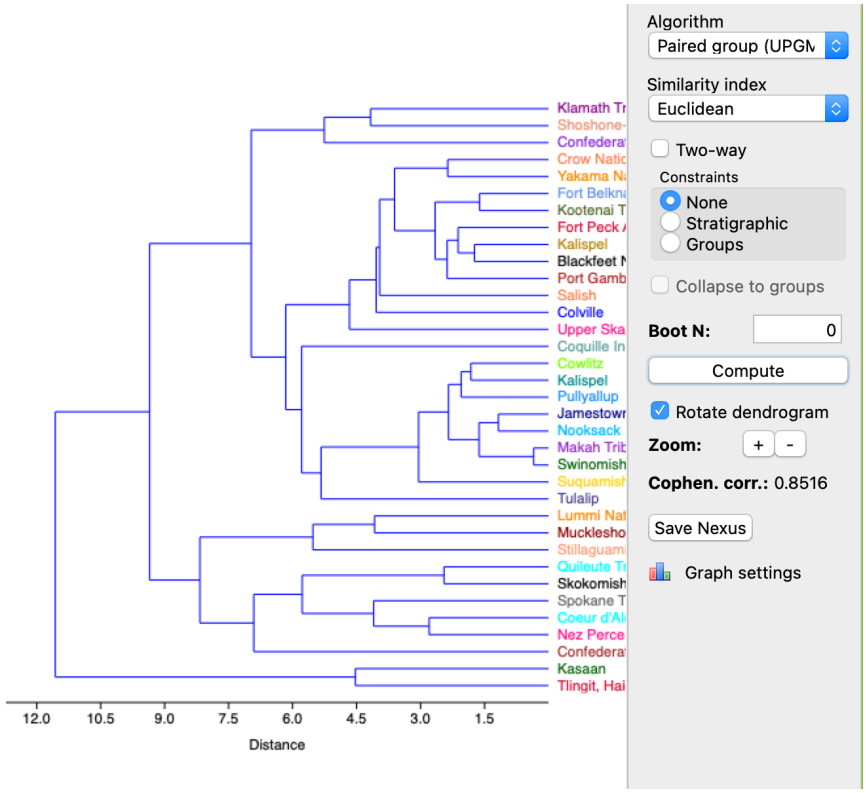
PC1xPC3 Biplot - depicting the relationships between each analyzed Pacific Northwest tribe and the various pollutants/pollutant impacts.

Table 1

Pearson's Correlation Analysis documenting relationships between each Pacific Northwest tribe (n = 34) and pollutant sources/impacts.

	Tribe #	State1	State2	GPS	CONT1	CONT2	CONT3	SR	S/C	W	A	L	F	MW	HI
Tribe #		0.49444	0.81561	0.55049	0.25223	0.5585	0.74678	0.39449	0.39449	0.8097	0.56412	0.25414	0.089323	0.62429	1
State1	-0.11942		0.52355	0.95476	0.30889	0.90705	0.18425	0.035384	0.23506	0.010213	0.87112	0.70926	0.87112	1	1
State2	-0.040887	-0.11154		0.94319	0.50732	0.41488	0.65329	0.10947	0.883	0.7377	0.71369	0.883	0.42158	0.49521	1
GPS	-0.10443	0.0099499	-0.012499		0.28619	0.89099	0.94346	0.97383	0.83813	0.019489	0.93433	0.16554	0.071486	0.26652	1
CONT1	-0.19881	-0.17707	0.1159	-0.18544		0.026894	0.3566	0.40705	0.35925	0.25438	0.00070793	1.8582E-05	0.098775	0.026898	1
CONT2	-0.10235	-0.020478	-0.14228	-0.024036	-0.37397		0.077691	0.14361	0.11749	0.12376	0.054997	0.44791	0.66683	0.3282	1
CONT3	-0.05659	-0.22976	-0.078668	0.01244	-0.16064	0.30217		0.023932	0.81309	0.64272	0.77313	0.69083	0.26378	0.70773	1
SR	0.14852	0.35679	-0.27529	-0.0057547	-0.14466	-0.25235	-0.38102		0.29179	0.21881	0.91431	0.33861	0.00177	0.4081	1
S/C	0.14852	-0.20603	0.025808	-0.03582	-0.15977	0.26947	-0.041453	0.18333		0.83941	0.91431	0.099078	0.025405	0.092604	1
W	-0.04222	0.42855	-0.058692	0.39309	-0.19793	0.26512	-0.081233	0.2132	-0.035533		0.43328	0.097921	0.43328	0.48115	1
A	0.1009	-0.02845	-0.064289	0.014452	0.54515	-0.32724	-0.050532	0.018871	0.018871	-0.13679		0.00066829	0.78858	0.25885	1
L	-0.19803	-0.065327	0.025808	-0.23966	0.65635	-0.13252	0.069677	-0.16667	-0.28333	-0.28427	0.54727		0.013136	0.4081	1
F	0.29149	0.02845	-0.14027	0.30838	-0.28358	-0.075402	-0.19414	0.50952	0.37743	0.13679	0.047009	-0.41517		0.25885	1
MW	0.085749	1.2114E-17	0.1192	-0.19305	0.37396	-0.17024	0.065689	-0.14434	-0.28868	0.12309	0.19612	0.14434	-0.19612		1
HI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Figure 5



UPGMA Cluster Analysis depicting clusters of tribes that share similar relationships among variables.

Commented [BSN3]: Swap with abbreviated version?