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Student Research Journal

Volume 3 • Issue 1 • Summer 2021

Brian Browne studying the effects of wind direction on the altitude of migrant birds.

Forward

As we navigate a new course in what it means to be a student and a scientific researcher during the ongoing pandemic, Headwaters Science Institute is excited to share the following research manuscripts from the 2021 Spring Research Experience. These manuscripts are the result of original research ideas developed by each student. Students molded the questions they were interested in and strengthened their scientific skills throughout the entire program to answer their questions. To accomplish this, students collected their own data or compiled existing datasets and then learned how to analyze and interpret their results. This ultimately led to the conclusions presented in the following articles.

The research completed by each student would not have been possible without an incredible group of professional scientists, post-docs, and graduate students. These scientists each brought unique knowledge to the program, and, as research mentors, they shared with students their own experiences in what it takes to conduct original scientific research. Thank you to all of the scientist mentors who provided the time and energy to not only make these projects possible but to help our students grow as scientific thinkers.

The breadth of research in this publication is a true testament to the creativity of the students in this program. These articles also highlight the fantastic job the scientist mentors did in promoting this creativity and in assisting the students throughout the scientific process. Although not peer-reviewed as is typical in academic journals, these articles have been reviewed by Headwaters staff and professional scientists. Each student worked incredibly hard to complete these manuscripts, and we encourage them to be proud of what this research represents. Each student fostered their curiosity while managing the setbacks, time constraints, and challenges that come with scientific research in order to author these papers. We extend a "congratulations" to all of our students highlighted in this issue!

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HEADWATERS SCIENCE INSTITUTE

STUDENT RESEARCH JOURNAL

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COVID-19 and the Mental Health Effects on Teenagers

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ABSTRACT

At every stage in life, mental health is important as it not only affects how we feel, but how we think and how we act as well. It determines how well we handle stress, relate to others, and make decisions. This study aimed to combat mental health stigmas by making connections between anxiety, coping mechanisms, and the global pandemic. We hypothesized that there will be an increase in anxiety behaviors and an increase in various coping mechanisms as a result of the pandemic due to social isolation and change. Teenagers were predicted to turn to coping mechanisms such as vaping and disordered eating in order to feel in control once again. The main objective was to find a correlation between circumstances, in this case, a global pandemic, and how teenagers react and cope with this hard change. This study was done using a survey, in which the results and responses supported our hypothesis, showing that mental health within teens declined as the pandemic hit. It also showed that many did not know they were struggling and coping in various ways until anxiety indicating behaviors were listed for them. The results help emphasize that understanding anxiety and other mental health symptoms can help the millions of teens struggling to seek help and effectively decrease stigmas around mental health.

INTRODUCTION

In the United States, one in every five adults have experienced mental health problems, one in ten teenagers have had a major period of depression, and one in every twenty five Americans live with a serious mental illness such as schizophrenia, bipolar disorder, or major depression (1). Mental illness symptoms are often mistaken or misdiagnosed due to a lack of accurate and accessible information. Stigmas and negative attitudes around mental health cause many to not seek help and therefore suffer alone in silence. More than half of the people with mental illness don't receive help out of the fear that they will be seen as "less than" or crazy (1, 2, 3). According to a study performed in 2017, involving more than 200 participants with mental illness, those with greater self stigma or shame, associated with poorer recovery after a period of two years (2). Raising awareness about mental health can help millions understand their symptoms and seek professional help. In addition, awareness will break the stigmas surrounding mental health that leaves so many suffering in secret (3). Our results show that this awareness gap has evidently resulted in many teenagers not being able to self diagnose anxiety and therefore suffer without knowing they need help. Our findings indicate that there is a lack of self recognizing capacity about anxiety, which stems from this lack of conversation around mental health and anxiety.

As COVID-19 impacted and altered millions of lives, mental health, particularly in teenagers declined dramatically (2) and although progress is being made against the virus through the availability of vaccination, mental health issues don't appear to be resolving as quickly (4). Students are stuck at home, isolated, and in need of ways to cope, according to the CDC. Adolescence is a crucial period for social development, thus, due to a loss of routine for many students in addition to social isolation, feelings of loneliness increase the risk of mental illness (5).

In dealing with this drastic change, many seek ways to cope and relieve built up anxiety. With the vaping industry booming, selling over 565 types of e-cigarettes as of 2017, many brands shifted marketing tactics to appeal to younger individuals (6). With flavors ranging from mint to birthday cake, younger audiences are more likely to try these products, often with misconceptions regarding the danger of nicotine in a developing brain (7). Due to the release of dopamine and epinephrine (adrenaline), nicotine is considered to be more addictive than cocaine, heroin, and alcohol. Developing brains build synapses faster than a fully developed brain, and because addiction is a form of learning, teenagers are more susceptible to becoming addicted to nicotine and faster (8). Within 10 seconds after inhalation, nicotine spreads throughout the brain, through the bloodstream (9). Along with the "buzz", you may feel, which is due to the release of neurotransmitters and hormones, other chemicals and ultrafine particles collect deep within your lungs. This buzz is often the feeling that many chase in order to relieve built up stress and anxiety, and therefore abuse vaping in order to cope with the feeling of being out of control.

As a result of the pandemic affecting mental health in teens, we hypothesize that there will be an increase in anxiety related behaviors such as vaping and a decrease in motivation. Because of this social isolation and change, teenagers will turn to coping mechanisms such as vaping in order to gain control in any way. This study investigates additional anxiety indicating behaviors such as nail biting, disordered eating habits, knuckle cracking, shortened attention spans, and trouble sleeping, in which many teens are experiencing throughout the pandemic.

METHODS

All the data was collected through a QuestionPro survey consisting of questions on mental health, the pandemic, and vaping. There were four main sections within the survey, about life during a pandemic, anxiety and mental health, vaping, and background demographics. The survey was distributed to high schools around California through assistant principals, while also sending it out to friends and other contacts.

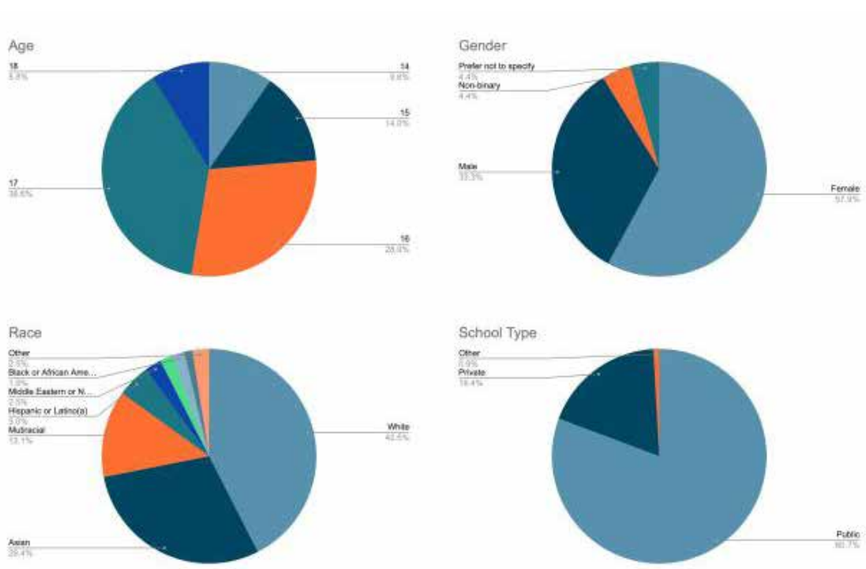

Figure 1. Demographic information collected (age, gender, race, and school type). n=157

The first section contained 6 multiple choice questions regarding people's general wellbeing during the pandemic. The purpose behind having these questions appear first was to start out with easier to answer questions, in hopes to increase the number of participants fully completing the survey. The next set of 5 multiple choice questions focused on anxiety and motivation, comparing these feelings before the pandemic versus now. Within this section, slider bars were used to indicate a rank of how they are feeling on a scale from 1 to 10. In the following section, students were asked to rank anxiety indicating behavioral statements based on how frequently they relate to them. To analyze the data collected in this section, each answer was given a number ("never" being 1, "sometimes" being 2, "often" being 3, "usually", being 4, and "always" being 5). The responses were added up and averaged to give each participant a score ranging from 20 to 39. The participants with higher scores were hypothetically more anxious than those with lower scores.

To calculate a person's anxiety levels, we listed 9 anxiety indicating behavior statements, in which the participant would rank. Then we gave each possible response a number in order to make a mean score for the individual ("never" being 1, "sometimes" being 2, "often" being 3, "usually", being 4, and "always" being 5).

The third section, consisting of 8 questions, some multiple choice, and some short responses, focused on vaping. The final section, the demographic questions, asked about school, parents' education, race, gender and age. These questions were multiple choice and checkbox options, as well as having an "other" response option for the questions that have the potential to be considered sensitive.

To analyze the data collected through the survey, Chi-Squared crosstab and unpaired t-tests were used and analyzed on a Google spreadsheet. In total, 157 individuals took the survey.

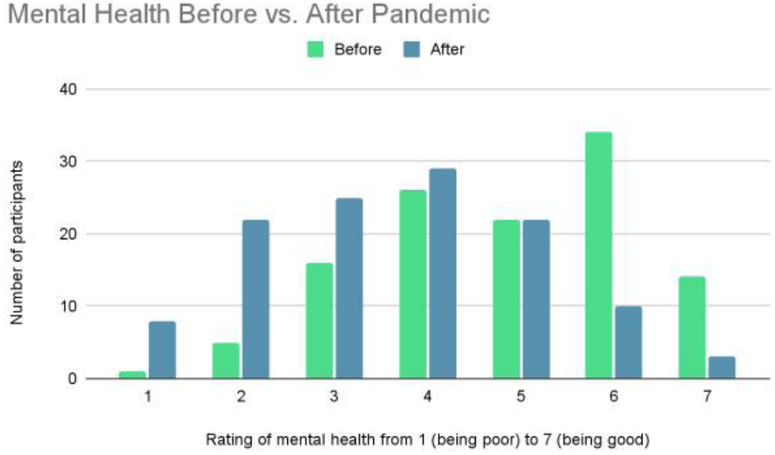

Figure 2 compares the mental health of participants before the pandemic and now, in May of 2021, showing that mental health has gotten worse as the pandemic hit. The mean score for the results for before the pandemic was 4.87 and the mean for the ranking after the pandemic was 3.62. The P-value was statistically significant as it was 0.0001.

RESULTS

This study was conducted using a QuestionPro survey which received 157 responses, of which, 19 reported to have vaped or vape. Representing the data collected, the figures below highlight the connections between mental health, age, race and coping mechanisms such as vaping.

Figure 1 shows the demographic information collected through the survey. These figures include age (Panel 1), gender (Panel 2), race (Panel 3), and school type (Panel 4). Panel 1 shows that out of the 114 participants to answer the question regarding age, 28.95% were 16 and 38.6% were to be 17. 57.89% participants were female. The participant's races are shown in Panel 3, concluding that about 42.5% were White, 29.4% were Asian, 13.1% were multiracial, 5% were Hispanic or Latino(a), 2.5% were Middle Eastern or North African and 1.9% were Black or African American. Panel 4 represents the type of school each participant attends.

The majority, 80.7% reported that they go to a public school, while 18.4% attend a private school.

Respondents indicated that their mental health during the pandemic was worse than before the pandemic (Figure 2). Participants were asked to rank their mental health on a scale from 1 to 10, 1 being unmotivated, unhappy, and struggling, while 10 being doing great, feeling happy and motivated. The mean for the responses recorded before the pandemic was 4.87 and the mean for after was 3.62. The P-value equals 0.0001, so statistically, the difference is extremely significant. The mental health in teenagers greatly declined as significantly more participants ranked their mental health lower on the scale than before.

The mean score for those who answered "yes" when asked if they consider themselves to be an anxious person to those who answered "no" to that same question are compared in figure 3. Those who answered "yes" had an averaged mean score of 28.33 and those

Figure 3. The anxiety behavior composite score for those who claimed they are an anxious person vs. the anxiety behavior composite score for those who said they weren't an anxious person. The p-value calculated through a t-test was not statistically significant as it was 0.1705. Error bars = 1 standard deviation.

who answered "no" had an averaged mean score of 26.97 (Figure 3). This 1.36 mean difference between those who identify as being an anxious person and those who don't is not statistically significant, emphasizing that many people who don't think they have any degree of anxiety are often mistaken. Evidently, these people are displaying behaviors that indicate having some form of anxiety; however, they aren't able to recognize or acknowledge that they are anxious without hearing the behaviors first. Figure 3, therefore shows the anxiety indicating behaviors used to determine one's anxiety levels as well as the insignificant t-test p-value of 0.1705.

DISCUSSION

We hypothesized that teenagers are experiencing worsened mental health due to the pandemic and therefore are using harmful coping mechanisms such as vaping in order to deal with the changes in their daily life. The results support this hypothesis as 100% of the respondents reported that their anxiety levels had increased since the pandemic hit. Results did indicate some response bias in that female, public, school, and white respondents were overrepresented compared to the demographics of California high school students. The majority of participants identify as female, go to a public high school, and are White, therefore there was a response bias. Although our initial goal with this study was to make a connection between stress and vaping, since only 14 participants admitted to vaping, our research question shifted to focus mainly on mental health and the effects the pandemic had on it. The lack of responses admitting to vaping demonstrates that the people who do vape are less inclined to be honest and admit to vaping or take a survey about vaping in the first place. Statistically, this group of people who took the survey are less likely to vape or be honest about vaping due to the their demographic background, however, other studies estimate that nearly 1 million teens vape daily in the US alone (10), indicating that even though the results from this survey suggest that very few teenagers vape, it is still a prevalent issue as a large population of the US is vaping underaged.

A section of the survey asked the participants to rank anxiety behavioral statements based on how often they experience them. A question earlier on in the survey simply asked if they consider themselves to be an anxious person. We found that many aren't able to sufficiently make a conclusion about their own anxiety levels as those who answered "yes" to being an anxious person and those who answered "no" had virtually the same anxiety composite score. This composite score was created by assigning each answer from the rank the statements section a number from 1 to 5, adding them all up, and averaging them to give each individual an score where the higher the score, the more anxious that person is. These results suggest that a majority of teenagers don't understand or can't identify anxiety until behaviors are listed for them.

Figure 4. Anxiety indicating behavior statements to help determine how anxious a person is to help understand if one is good at self evaluating poor mental health symptoms.

Stigmas around mental health prevent millions from seeking the help they need in order to overcome their struggles (10). With this lack of awareness around poor mental health symptoms, we found that there was a large population of teenagers who couldn't see that they had high levels of anxiety as they may have assumed their struggles were not related to a mental health condition. Those suffering in silence may be because of stigmas around mental health, but we now know that they may also not be able to acknowledge that they have mental health issues. Mental health matters as it affects everything a person can do whether it is as simple as getting out of bed in the morning or performing well in sports. Without a strong mindset and good mental health, daily tasks can feel impossible.

If this experiment were to be conducted again, it should be sent out to a bigger population so there is more diversity within age, gender, race, and school type which will hopefully result in more teenagers admitting to vaping in order to get a more accurate representation. Future scientists can use the results we gathered to understand how the pandemic specifically affected the mental health within teenagers as it is fresh in everyone's minds in 2021. Adding onto these results with more accurate data regarding vaping is crucial as learning more about how teenagers cope with change can help future generations avoid these harmful coping mechanisms when it comes to dealing with mental health issues. These results clearly show that teenagers are struggling with being isolated and not having control due to the pandemic, emphasizing not only a need for mental health issues to be destigmatized but for an increase in mental health education and awareness as well.

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Comparing effects of NaCl to CaCl Ice Melt

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ABSTRACT

In order to properly maintain the natural beauty of our watersheds, it is critical that we diligently monitor their health in order to protect the macroinvertebrate communities and sustain a healthy environment(1). This experiment addresses the effects of NaCl-based De-Icing melts versus CaCl melts on chemical levels and conductivity in water. This research is very valuable as it demonstrates the effects of small changes to water toxicity on a fragile environment. When Ice Salt infiltrates the aquatic ecosystem, the new stimulus forces macroinvertebrates to migrate and destroys the ecosystem(1). Repeated measures experiments were ran to test the levels of ppm, pH and conductivity across various ice salt melts. Specifically NaCl and CaCl melts were tested. Results showed that at 300mg, the p-value was above 0.05 showing significant differences between brands for both PPM and conductivity. The first brand (CaCl) had a lower mean PPM and conductivity than the second brand (NaCl) throughout all repetitions of this experiment. PH was not significantly different across brands. This data was collected in a controlled environment and if the results are likewise in nature, precautions must be made to lower the effects of NaCl deicer as it causes more changes in water PPM and conductivity, which can be harmful to aquatic ecosystems.

INTRODUCTION

Over 13,719 gallons of Ice salt melt are dumped into Truckee Tahoe's roads every winter to clear ice off of roads. Once the snow melts, the Ice Salt is carried through runoff into rivers and streams and eventually deposits chloride into the river(4). The implications of this runoff into river ecosystems includes drastic changes in the water's toxicity levels by changing pH, PPM, salinity content, and conductivity(5). According to a study by Steven et al. (2010), 72% of river water showed toxicity and chloride concentrations exceeded U.S. Environmental Protection Agency water-quality criteria at 55% and 100% of monitored sites(4). Ice Salt Melt is a chemical substance using either sodium chloride, magnesium chloride, or calcium chloride to melt ice and snowpack on roads so it can be safer to drive or walk on. When the Ice Salt Melt's main ingredient is sodium chloride, I predict the effects will be larger on increasing PPM, pH, and conductivity as opposed to calcium and water-based mixtures. Some research has been done on the effects of widely used Rock Ice Salts using sodium chloride (5), but there is still a knowledge gap comparing the effects of NaCl Ice Salt to CaCl Melts. CaCl melts are relatively new to the market due so few experiments have been conducted on its effects on aquatic ecosystems through runoff.

According to a study by Kelly et al. (2012), about 14% of the road salt is retained in the subsurface of the soil, approximately 50,000 metric tons of NaCl annually. Of this 14%, most are made up of NaCl as this alternative is much cheaper and common than CaCl(3). The two leading Ice Salt Melt brands in the Tahoe Truckee area are Snow Plow Ice Melt and Diamond Crystal Ice Melt. Diamond Crystal Ice Melt is mainly composed of NaCl. According to a study by Victoria et al. (2008), sodium concentrations increased in the watershed by 0.9 mg/L per year over 19 years, and the salt used for deicing accounted for 91% of the sodium chloride input to the watershed. (4) The other brand, Snowplow Ice Melt, is mainly made up of a CaCl mixture and little to no research has been done testing the effects of CaCl in watersheds. It is critical to the health of our aquatic ecosystems and watersheds to monitor the effects of these CaCl based ice salt melts in order to manage healthy ecosystems and water sources.

METHODS

To better understand the effects of a NaCl Diamond Crystal mixture versus the Snowplow CaCl Mixture on water PPM, pH, and conductivity levels, I tested these differences using a treatment-control experimental design. The independent variable, Ice Salt, remained constant throughout the experiment as well as the tap water PPM, pH, and conductivity as the independent variables. In order to properly find a viable range of Ice Melt contaminating the water, 2 sets of 10 repeated tests were conducted for both 100mg and 300mg of either CaCl brand or NaCl brand. This study was conducted using tap water from the Truckee Tahoe CA region. In all experiments for both brands and variants, exactly one cup of tap water was collected and tested for original PPM, pH, and conductivity. After the desired amount and brand of Ice Salt Melt was inserted into the tap water using an American Weigh Scale and thoroughly mixed with a metal spoon and set for 10 minutes allowing it to properly settle. Once settled, the same cup of tap water was tested to find the new PPM, pH, and conductivity. All tap water used was collected from the same source using the same measuring cups. Experimental materials include Snow Plow Ice Melt (CaCl brand), Diamond crystal (NaCl brand), American Weigh Scale, TDS monitor, and Hannah instruments pH tester.

RESULTS

After analyzing all of my data, two patterns were revealed. The statistical test I ran was a two-sample t-test using the T-Test online Calculator by Graph Pad Prism. As you can see in the graphs below, the first pattern showed that when Ice Salt levels were at or above 300 mg, the p-value comparing Snowplow (CaCl brand) and Diamond Crystal (NaCl brand) for PPM and conductivity was above 0.05, indicating a significant difference between brands. This proves that the two brands change water PPM and conductivity. The mean PPM and conductivity were also consistently higher in the NaCl brand, making it more toxic than its counterpart. I believe this pattern exists due to the lower costs of NaCl-based Ice Melts and the increased need for transportation. According to a study done by Xianming Shi et al, (2009) CaCl (s) costs $20.00 to $42.00 per ton delivered to all regions in Colorado, whereas NaCl costs $10.00-$20.00(5).

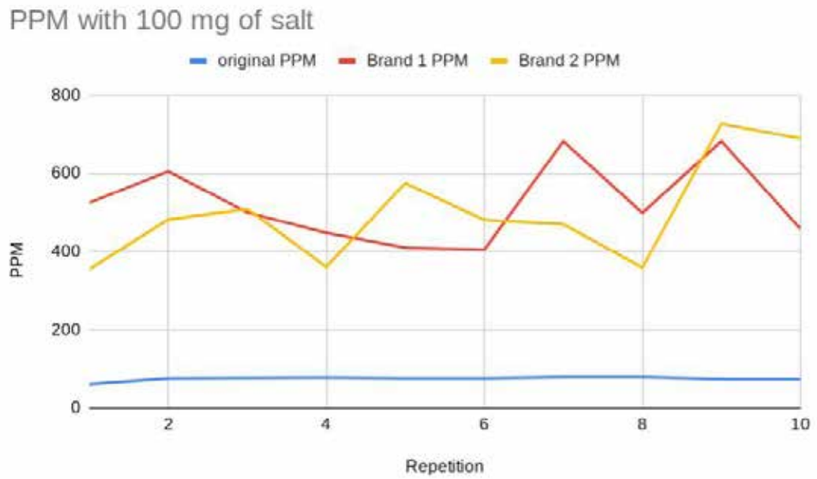

Figure 1: The x-axis represents the repetitions using 100 mg of salt and the y-axis shows the PPM present in the tap water. Brand one is the CaCl brand while brand two is the NaCl brand.

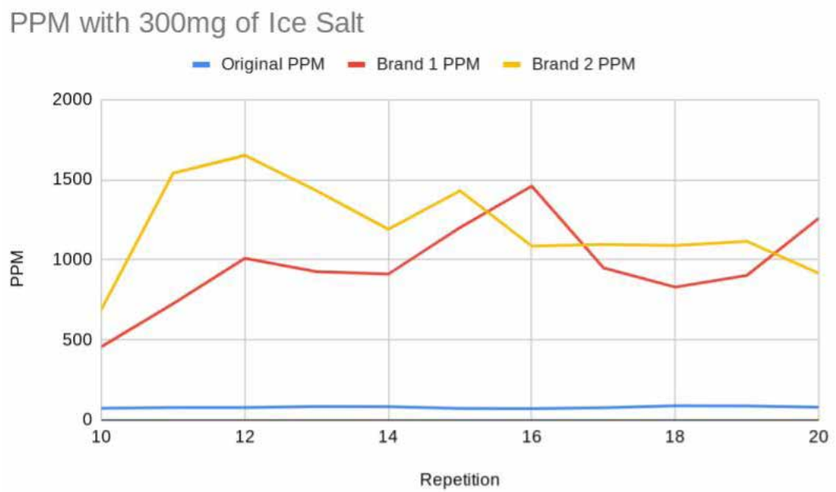

Figure 2: The x-axis represents the repetitions using 300 mg of salt and the y-axis shows the PPM present in the tap water. Once again brand one is CaCl and brand 2 is NaCl. At 300 mg in ppm test, P was less than 0.05 meaning there is a significant difference between brand one and two.

After analyzing my data, it was apparent that my hypothesis on the different brands changing water pH was wrong. The tap water's pH had very little variability between brand one and two (P>0.05). I hypothesize that if this experiment had higher concentration levels, a variability in pH would be present. For the NaCl brand, the pH mean was 6.99 for 100mg and with 300mg the mean was 7.32. For the CaCl brand, 100mg mean was 7.04 and 300mg mean was 7.5. This conclusion shows that both the NaCl and the CaCl Ice Melts had a much larger effect on water PPM and conductivity rather than pH due to chemical composition.

DISCUSSION

Ice Salt Melt is and will always be a necessary component of winter road work. There are some other alternatives to NaCl and CaCl like coffee beans and sand, but they are less popular. According to a study by Rasmussen et al, a main climate change impact is the snowpack and the increased snowfall at higher elevations. Truckee Tahoe has an elevation of 8817 ft, making it an alpine biome(4). Due to climate change, snowfall levels are varying, and at times, tremendous amounts of snow will all fall at once rather than spread out resulting in large snow-ins and blizzards. With all this snow comes the need to clear it, and therefore requires more Ice Salt Melt to be used causing more to come in the rivers affecting more ecosystems by altering toxicity levels(4). A relatively simple way to reduce the impact of Deicing Road Salt is to initiate a pick-up crew within the road service to come after the snow has melted and pick up all the excess Ice Melt. This will prevent these Ice Salts from contaminating water sources and will mitigate their negative effects on the environment no matter the main chemical.

According to this study, Deicing Road Salts containing the main ingredient NaCl have a larger effect on changing water PPM and conductivity than CaCl based Road Salts. It is critical that environmental and city road managers recognize the potential harmful impacts of using De-Icing melts. Future controlled experiments could test varying concentration levels across a wider variety of De-Icing melts. Experiments could compare different geographical regions across the globe and use new controls including lake and river water. Results may shed more light on the issue and lead researchers to explore the impacts of these products across naturally occurring rivers and stream ecosystems. In the Truckee Tahoe region, Ice Salt is a necessity for the well-being and productivity of the population and allows for travel during snow storms or blizzards. NaCl Road Salt has been shown to be more popular due to its lower prices but it also has larger negative effects on the environment, mainly water ecosystems(5).

When you change the PPM in an aquatic ecosystem, this alters the environment of the different macroinvertebrates currently living there and may cause them to migrate(1). These macroinvertebrates are an important factor in the food chain and when they are forced to migrate, then everything above it on the food chain is forced to either starve or migrate as well. Additionally, Deicing road salt has been shown to have negative impacts on not only aquatic ecosystems but also on dogs(2). According to the Brookfield animal hospital, When a dog walks over the Ice Salt, mainly NaCl-based melts, some get stuck underneath the pads on their feet and cause discomfort. The dog then attempts to lick their paw and accidentally ingests the Salt which in large amounts can be fatal(2). The NaCl Road Salt can be very dangerous to both macroinvertebrates and dogs and if at all possible, the CaCl based Salt should be used.

In conclusion, the NaCl has much more of a negative effect on the environment by causing large changes in water PPM and conductivity(4). These changes have large effects on macroinvertebrates' environments by causing them to migrate therefore starving all things dependent upon them as well as a danger to dogs by causing discomfort in their paws and possibly leading to ingestion which can be fatal (2). In order to mitigate these effects, one course of action is to create and/or implement a pickup crew to come after the storm and collect all the excess Deicing road salt melt. This system is already being incorporated into the road crew in Truckee CA. Another potential question researchers could investigate is how significant are the efforts of the road crew? This system could drastically lower the amount of Ice Salt making its way into streams and water sources and could therefore mitigate the negative effects the road salt has on the environment and animals no matter the brand. In addition, future research should closely monitor stream chemical levels across geographic regions with accumulated snowfall and subsequent deicing practices. Moreover, research should also monitor soil health as this soil can eventually make its way into streams and create the same problems. On a smaller scale, the CaCl De-Icing Melts are much better for the environment versus the NaCl-based mixtures and when given the choice, we should choose these more eco-friendly (and affordable?) de-icing melt options.

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Comparison of Water Quality between Cedarville State Forest and Patuxent

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ABSTRACT

Water quality is of paramount importance to human survival because it is essential to humanity itself. Testing water quality is necessary because it does not only tell of how humans and other impacts are affecting riverside and aquatic ecosystems but also has implications for human health as well. Patuxent River is a prominent body of water on the East coast that flows through central and Southern Maryland as well as draining into the Potomac River in our nation's capital. It is a very important ecosystem in Maryland, yet its natural coastlands and riverbanks are being impacted by humans. This experiment compares water quality between two bodies of water, one that is mostly unaffected by human activity, Cedarville Pond and Wolf-Den Creek, and one that is directly and daily affected by it, Jug Bay of the Patuxent River.My results show that Cedarville possessed a moderately acidic pH and no nitrate, while the Patuxent River had elevated levels of nitrate and a slightly basic pH. This confirms the hypothesis that the Patuxent River has lower water quality because of human encroachment and the lack of measures to prevent it. This experiment explores those results thus making a statement about the water quality of our most essential bodies of water.

INTRODUCTION

One in four people suffer worldwide from water pollution worldwide, it is vital that water pollution studies like this are done around the globe to identify water pollution to then acting on it. This experiment compares local bodies of water in Maryland to evaluate water quality. The two bodies of water being tested are Jug Bay, which is located in the tidal area of the Patuxent in Southern Maryland, and Cedarville Pond, along with a branch ravine called Wolf-Den Creek, both of which are located in Cedarville State Forest. Patuxent River, in general, is being affected increasingly by humans while the State Forest is widely exempt from such influences. Patuxent River is rapidly being developed industrially and agriculturally, transforming into an economic hub. Additionally, residential development is also being expanded around coastal areas of the Patuxent. For instance, 34% of nitrogen and nitrate in Patuxent originates from urban runoff while 22% comes from agricultural sites(Bevan-Dangle & Tutman, 2007). To evaluate the impacts, nitrate, nitrite, pH, alkalinity, total hardness, total chlorine, and Total Dissolved Solids (TDS) were measured, but nitrate and pH will be prioritized in the results because of those two factors being the most relevant. Excessive nitrate can cause eutrophication promoting algae blooms that kill marine life, specifically fish because of the lack of oxygen and based on the acidity or alkalinity of the pH determines the diversity of conformity as well as the marine presence of organisms. I hypothesize that Jug Bay will have elevated levels of nitrate and pH compared to Cedarville because of nearby agricultural sites. My results show that the Patuxent River does have increased nitrate and pH levels. In contrast, Cedarville State Forest Pond and Wolf-Den Creek had non-existent levels of nitrate and neutral pH levels.

METHODS

The first step one must undertake is establishing a secure, riverside site along Jug Bay, only data taken at riverside sites were recorded. The next course of action would be to utilize Tetra water strips that display nitrate, nitrite, hardness, chlorine, alkalinity, and pH. Follow the instructions according to the water strips located on the back of the container concerning its use. Secondly, record results of all measurements in the lab journal. Obtain at least two-three trials for each section of water tested. Then completely pack up and clean

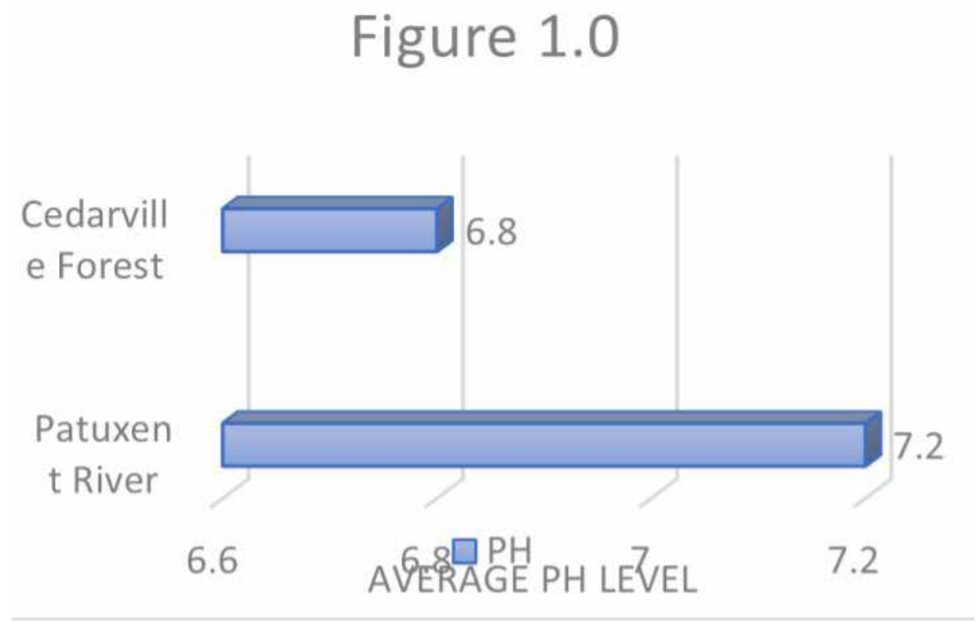

Figure 1: Average pH of Cedarville Forest and Patuxent River. Cedarville forest exhibited a mean pH of 6.8 compared to Patuxent at 7.2**.**

the site and establish at least seven more sites at each body of water undertaking the same operations. Then calculate the averages of the ph and nitrate specifically.

RESULTS

Figure 1.0 displays the results of the average ph of both bodies of water. Both ph levels within Patuxent and Cedarville are neutral, but Patuxent River is more "alkaline-leaning" while Cedarville State Forest is slightly acidic. Cedarville Forest has a mean ph of 6.738 while Jug Bay's average pH entails 7.325. The p-value (probability value) attained via t-test for the difference between mean pH of both locations equals 0.0008 which is a statistically significant margin. Figure 2.0 displays the contrast between the nitrate levels. Cedarville Forest contained no nitrate within its bodies of water, while Patuxent River had average of 15 units of nitrate which is the common measurement of NO3. The two-tailed p-value for the difference between mean nitrate of both locations is less than 0.0001. This is a statistically significant margin of difference between the two nitrate levels of the two bodies of water and can further be exhibited via this chart. The chart below further displays both figures.

DISCUSSION

The results of this study support my hypothesis by showing that Patuxent River has heightened nitrate levels relative to Cedarville as well as a more alkaline-neutral, average pH. Adjacent agricultural and industrial sites are likely responsible for elevated nitrate levels in the Patuxent River because agricultural runoff can carry excess fertilizers into nearby bodies of water[cite]. Continued exploitation of natural coastlands and riverbanks will only serve to elevate Patuxent's already heightened nitrate levels. Cedarville

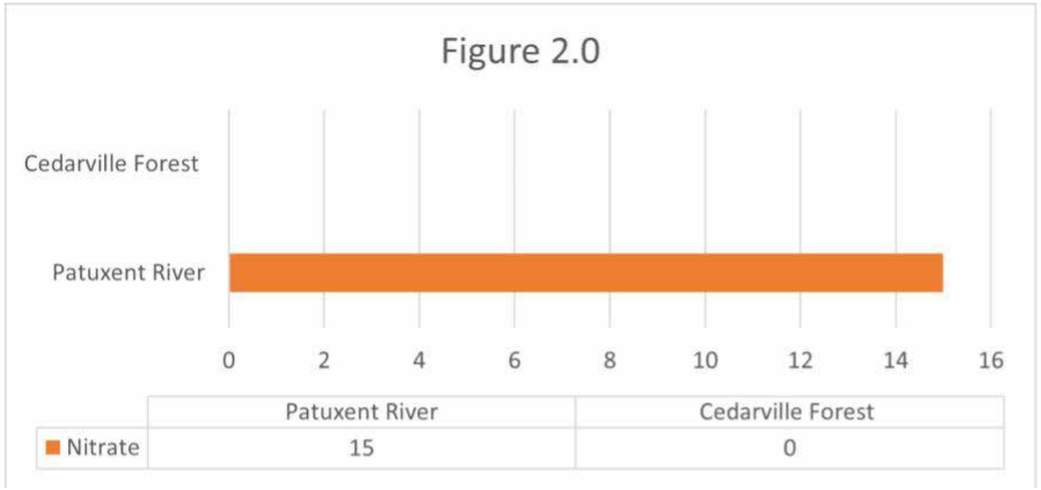

Figure 2: Average nitrate levels between bodies of water**.**

Forest, whose bodies of water of which are wholly unaffected by previously mentioned human activity as a result of it being a protected area, has non-existent nitrate levels and more so a directly neutral pH.

Thus it is concluded that Cedarville is the healthier body of water and that decisive legislative and local action must be taken to secure Patuxent's future as an invaluable ecosystem and as an icon of the American Eastern shore. Heightened industrial, agricultural, and residential encroachment dare to undermine the natural beauty and essence of the Patuxent River. Cedarville State Forest and the bodies of water served as a comparison and revealed just how much human impact can affect the quality of a body of water contrasted to another body of water that is wholly exempt from it. Efforts have been made to in part restore the Patuxent and those partial restorations are of immeasurable value yet environmental legislation and implementation need to be headed by the state to create mandatory and decisive action on the issue of Patuxent's water quality crisis. Yet this in conjunction with local and individual and group actions must take place simultaneously to decrease detrimental human-caused variables such as this.

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Examining the Efficiency and Accuracy of Mineralogy Point Counting

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ABSTRACT

Here we examine the efficiency and accuracy of point counting, a common method used by geologists and mineralogists to determine the proportions of minerals within a rock. We used samples from a volcano in Nicaragua to compare the results of three grid spacing lengths, 1 cm, 3 cm, and 5 cm. We used confidence intervals to estimate the mean for the four components including two minerals (mafic and feldspar), groundmass, and bubbles of air. Comparing the ranges of these intervals showed interesting results: out of the twenty comparisons between the 3 cm and 1 cm intervals, there were no pairs of intervals that failed to overlap (i.e., no statistically significant difference) and out of the twenty comparisons between the 3 cm and the 5 cm intervals, there were no pairs of intervals that failed to overlap, however, out of the twenty comparisons between the 5 cm and 1 cm intervals, there was one pair of intervals out of the twenty that failed to overlap (i.e. statistically significant difference). This suggests that 3 cm sheets do not have statistically significant differences compared to the 1 cm sheets and compared to the 5 cm sheets, but that the 5 cm do have statistically significant differences compared to the 1 cm sheets, implying that 3 cm sheets can be used instead of 1 cm sheets. These results can help increase the efficiency of point counting and save time while still maintaining non-statistically significant differences in observed proportions of components.

INTRODUCTION

Point counting has been an effective method, used by geologists and mineralogists, to estimate the proportions of minerals and other components within a rock sample. Before modern technology was invented, mineralogists and geologists relied solely on their eyes to help estimate the proportions of minerals within rocks. The issue with this method is that the human eye can be biased (1). To compensate for eye bias, French geologist Achille DeLesse decided to base mineral proportions on area ratios (1). He came up with a procedure where he would trace the minerals from a sample onto a piece of wax paper then count the total distance of that mineral of which he traced over. That would be proportional to the area of the components, as the size of the perimeter of a mineral is directly proportional to area. Essentially, he would trace over the present minerals and use Equation 1 as an estimate of the proportions of minerals within the rock:

Equation 1: Relative amount of mineral = length of mineral traversed / total length traversed (1).

However, researchers and mineralogists discovered a more accurate and organized method of estimating the proportions of minerals within a rock. Known as point counting, the method estimates the proportions of minerals within rock by tallying or counting minerals found at a grid intersection (Equation 2). Different grid spacings can be set, however, there is a tradeoff between the number of points and time spent vs. the accuracy of the results.

Equation 2: Proportion of mineral A within rock = total count of mineral A at grid intersections / total points counted (1).

One goal for the future of point counting is to reduce the time needed to estimate the proportions of minerals within a rock, which has prompted the development of machine learning and AI to carry out the actions that a human would (i.e. the computer would create and record the minerals at each crosshair). There

exists supervised machine learning that attempts to replicate a human conducting point counting, but the models do not reproduce the accuracy and level of precise identification that manual point counting does. However, the model does provide a clear overview of the dataset and rock, and can identify the type of minerals to a certain extent (2). In addition, other techniques such as computer controlled electron microscope scanning with an energy-expensive x-ray spectrometer have further increased the automation of point counting (3). However, our research focuses on reducing time and increasing efficiency of manual point counting.

In this paper, we examine the relationship between different point counting grid spacings, 1 cm vs. 3 cm, 1 cm vs. 5 cm, and 3 cm vs. 5 cm. We hypothesize that the 1 cm sheets will not display any statistical significance when compared to the 3 cm sheet. We also hypothesize that the 3 cm sheets will not display any statistical significance when compared to the 5 cm sheet. But, we believe that the 1 cm may perhaps display statistical significance when compared to the 5 cm sheet. This is because 5 cm is quite large compared to 1 cm, and thus there is room for variability in our results and data, which could potentially be statistically significant.

METHODS

In order to examine the relationship between different point counting grid spacings, 1 cm vs. 3 cm, 1 cm vs. 5 cm, and 3 cm vs. 5 cm, we examined five thin sections of rock from a volcano in Nicaragua. The samples are from the same type of rock containing the same minerals and traits with slight variance, limiting potential variability in the results. These rock samples contain minerals, bubbles of air, and groundmass and were scanned in plane-polarized light, so as to not introduce unwanted reflections (which would decrease clarity and accuracy). We researched the mineral habit (such as shape, color, cleavage, etc.) and determined that our four findings, feldspar minerals, mafic minerals, groundmass, and bubbles of air, have the following traits and characteristics:

- Feldspar is clear and rectangular. Mineral fractures (cleavage) are at 90-degree angles.
- Mafic minerals (olivine and pyroxenes) are light green colored and are roughly the same size and shape.
- The groundmass is microcrystalline black matrix material.
- Bubbles of air are oblong to spherical vacancies.

Scanned samples were printed out on 21.6 cm x 27.9 cm paper sheets. For each of the rock samples (n=5), the proportions of the different components present in each sample were calculated using three different grid spacings (1 cm, 3 cm, and 5 cm). A typical 1 cm sheet contains roughly 290 crosshairs, a typical 3 cm sheet contains around 96 crosshairs, and a typical 5 cm sheet contains around 48 crosshairs. We recorded the minerals, bubbles, and groundmass at each crosshair and calculated the percentages of each.

We then created confidence intervals for each mineral, bubble, and groundmass within each of our fifteen unique sheets (five 1 cm sheets, five 3 cm sheets, and five 5 cm sheets), resulting in sixty total confidence intervals. We then compared the ranges of our confidence intervals by testing the 1 cm vs. 3 cm, 1 cm vs. 5 cm, and 3 cm vs. 5 cm.

Sample 1	Feldspar	Mafic	Groundmass	Bubbles	Total
Total counts (1 cm)	58	31	109	90	288
Proportions (1 cm)	20%	11%	38%	31%	100%
Total counts (3 cm)	15	9	43	29	96
Proportions (3 cm)	16%	9%	45%	30%	100%
Total counts (5 cm)	10	1	20	17	48
Proportions (5 cm)	21%	2%	42%	35%	100%

Table 1. Total counts and proportions for the four observed components, feldspar, mafic, groundmass, and bubbles of air, for sample 1 of 5, across three different grid spacings.

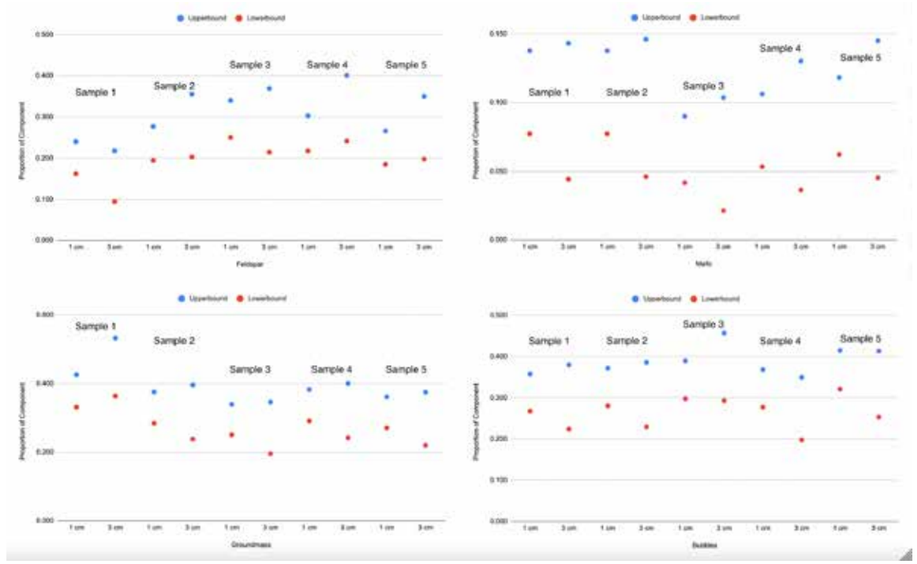

Figure 1: Component comparison for 1 cm and 3 cm grid spacing. Graph of confidence intervals for the four observed components, feldspar, mafic, groundmass, and bubbles of air, for the 3 cm vs. 1 cm spacing.

All four conditions (randomization, independence assumption, 10% condition, and at least 10 conditions for successes and failures) that need to be satisfied in order to create these confidence intervals were satisfied (4). We proceeded to compare the ranges and record our results, noting whether confidence intervals overlapped (no statistically significant difference) or did not overlap (statistically significant difference).

RESULTS

Out of the twenty comparisons between the 3 cm and 1 cm confidence intervals, there were no pairs of intervals that failed to overlap, however, out of the twenty comparisons between the 5 cm and 1 cm intervals, there was one pair of intervals out of the twenty that failed to overlap (Figure 2). Between the 5 cm and 3 cm, there were no pairs of intervals that failed to overlap.

We tested our hypothesis by comparing the ranges of the confidence intervals to one another — for each mineral, bubble of air, and groundmass data collection. We compared the range of the confidence interval for the 1 cm sheet to the range of confidence interval for the 3 cm sheet, the range of the confidence interval for the 1 cm sheet to the range of confidence interval for the 5 cm sheet, and the range of the confidence interval for the 3 cm sheet to the range of the confidence interval for the 5 cm sheet. Since confidence intervals and hypothesis tests are directly related, if two confidence intervals fail to overlap (within their respective ranges), there is no data shared between the two, and the difference in component percentages are statistically significantly different between the two samples. On the other hand, that means that if the two intervals do overlap, the difference in component percentages is not statistically significant.

DISCUSSION

Our data analysis showed that for the twenty pairs of confidence intervals comparing the 1 cm range to the 3 cm range, no pairs failed to overlap, meaning that there is no statistical significance between the two ranges for all observations. This suggests that

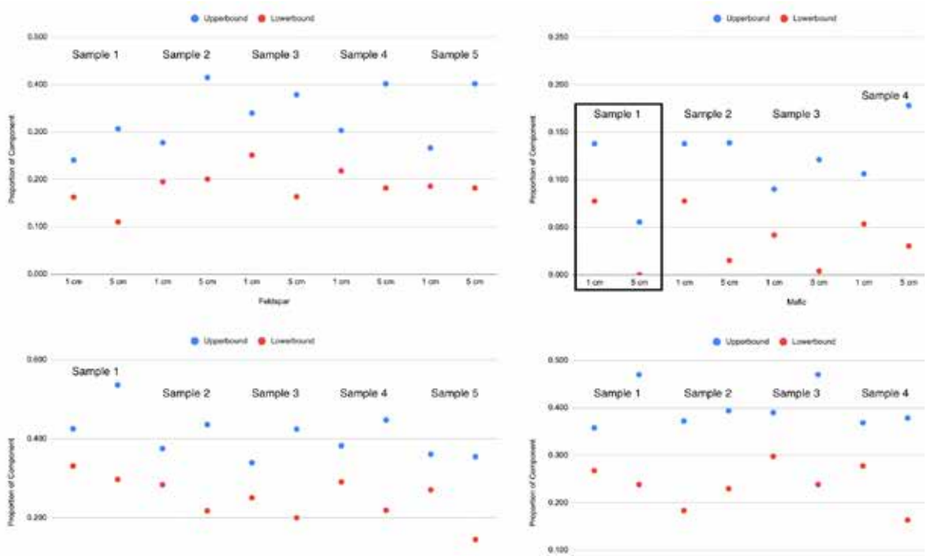

Figure 2: Component comparison for 1 cm and 5 cm grid spacing. Graph of confidence intervals for the four observed components, feldspar, mafic, groundmass, and bubbles of air, for the 5 cm vs. 1 cm spacing. The black box represents the one pair of intervals that failed to overlap, implying statistical significant differences in data.

the 3 cm grid spacing produces results that are not statistically significantly different compared to the 1 cm, and that it is possible to use the 3 cm grid spacing for these samples to save time and increase efficiency. Efficiency implies saving time while keeping accuracy to a non-statistically significant degree, which would increase the potential for other research and time spent. However, for our twenty pairs of confidence intervals comparing the 5 cm range to the 1 cm range, one of the twenty pairs failed to overlap, meaning that for that particular pair there was a statistically significant difference between the data recorded. In addition, there was no statistical significance between the 3 cm range and the 5 cm range. This suggests that for our data collected for the two respected ranges, 3 cm and 5 cm, 3 cm should be chosen as the most efficient range that still produces results that are not statistically different compared to 1 cm grid spacing. That way, accuracy is not lost, and time is saved.

However, there are several considerations for the discussion of these results. For one, this data analysis was based on a total of five samples from a single volcano in Nicaragua. The samples were taken randomly, however the data from the samples may have been biased — for example, the samples may have had data that had an extreme amount of a certain mineral or component in comparison to the population average amount. For example, throughout this experiment, the presence of the mineral mafic was always less than 15%. An extreme amount would be if one sample had 30% or 40%, whereas all the other samples fell below 15%. This sample data could have introduced a flaw in our data analysis, which was only conducted using these five sample sheets. To compensate for this potential error, more rock samples could be used in a future study. Second, although point counting aims to eliminate bias in recording the minerals, by using equally spaced crosshairs, there were numerous times where a crosshair fell in between two minerals, and I randomly picked one because it was too difficult to distinguish between the two minerals or components. Although I claim to have made this selection "randomly", there is likely subconscious bias which may have influenced my results.

In addition, for the future, it would be worthy to examine different rocks from different parts of the world. Rocks vary in mineral composition from area to area — for example, granite contains very distinct mineral features such as visible clumps of feldspar, quartz, and mica, which can be seen with the naked eye. On the other hand, the rocks I examined from the volcano in Nicaragua, had minerals which could only be distinuged on a microscopic scale. To test that potential natural or coincidental bias, more rocks could be tested, with the exact same approach and methods. It would be interesting to see the results of other rock types — more specifically, are there rocks that a 3 cm grid spacing would not be sufficient for identifying component percentages? Or on the other hand, are there rocks that a 5 cm grid spacing would be sufficient for identifying component percentages?

In short, we examined multiple grid spacing ranges for point counting and found that length is a factor that can influence the accuracy of the results, more specifically, determining whether the differences in data observed at the various ranges were statistically significant.

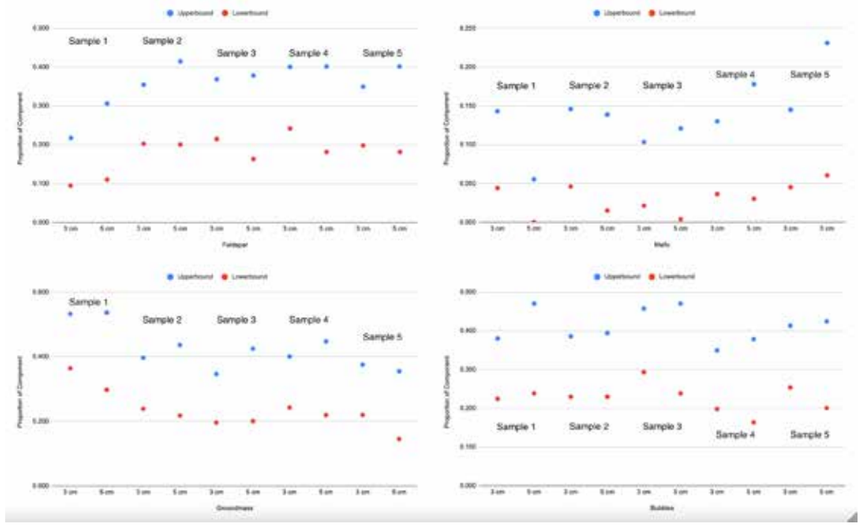

Figure 3: Component comparison for 3 cm and 5 cm grid spacing. Graph of confidence intervals for the four observed components, feldspar, mafic, groundmass, and bubbles of air, for the 5 cm vs. 3 cm spacing.

ACKNOWLDGEMENTS

I would like to thank Spencer Eusden, Le'a Gleason, and Meg Seifert for giving me the opportunity to conduct scientific research and pursue this passion of mine, as well as my parents for supporting me throughout this journey.

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Effects of Wind Direction on the Altitude of Migrants Birds

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ABSTRACT

Migration is an extremely energetically taxing and dangerous behavior for birds. Therefore, understanding migrant birds' behavior especially in differing weather conditions is important. This study was conducted to examine the effect wind direction has on the altitude that birds migrate. We hypothesized that on days with northern winds, birds migrating north will fly lower, below the ridgeline, and on days with southern winds, birds will fly higher, above the ridgeline. Our results concluded that this prediction is true, with the vast majority of birds below the ridgeline on northern wind days and the opposite for southern wind days. One can infer that as birds attempt to maintain flight efficiency on their journey north in the spring, they fly in more sheltered canyons when faced with a northern headwind to limit wind resistance. Alternatively, migrating birds fly higher, above the ridgeline when faced with stronger southern winds where tailwinds may help to maximize flight efficiency. The energy saved could save their life as they traverse hundreds, if not thousands of miles, depending on the species.

INTRODUCTION

The migration patterns of birds are incredibly complex, from how they navigate to how they respond to their environment. Their methods of navigation vary, some including tapping into the Earth's magnetic field or using the stars and landmarks (1). A large number of birds migrate at night, especially passerines, but diurnal migrants can be observed overhead in the northern hemisphere on their journeys north during spring and south during fall (2).

A tactic that terrestrial diurnal migrants employ during migration is to follow ridgelines, as they create updrafts and serve as landmarks (3). This leads to concentrated highways of many different migrants. For example, in California, many birds migrate north across the Golden Gate span at the mouth of the San Francisco Bay in the spring. They then fly north up the Marin Headlands, splitting either west towards the coast and Point Reyes, or following ridgelines that lead up to the base of Mt. Tamalpais. Between the towns of Mill Valley and Corte Madera, Blithedale Ridge joins with Corte Madera Ridge, curving around the east side of Mt. Tamalpais. This creates a funnel for birds that travel on the bayside of Marin County.

Migrating birds are heavily affected by weather, causing them to alter their behavior (4). Wind can either be greatly beneficial or greatly detrimental, depending on its direction compared to the direction of a migrating bird. Birds have been found to delay travel during unfavorable wind, and the highest number of migrants are recorded when they have a tailwind (4, 5).

In this study, we investigated the effects of northern and southern winds on whether spring migrants flew above or below a ridgeline. We predicted that on days with a northern wind (wind coming from the north), more birds would fly below the ridgeline and on days with a southern wind (wind coming from the south), more birds would fly above the ridgeline as birds attempt to maintain the most energetically efficient course (5). Due to the fact that birds migrating in the spring fly north, a northern wind will be a hindrance to them, so we expected that they would fly in lower, more sheltered areas where the wind speed is lower. Migration is extremely energetically expensive for birds, so making sure that they are minimizing wind resistance and maximizing thrust gained by a tailwind is critical to raising their chances of survival. Only 29% of the total avian population in the U.S. and Canada is left compared to populations fifty years ago (6). Migration is one of the most dangerous events in a bird's life (7), and studying their behaviors and patterns in various environmental conditions can build on the understanding of decision making in avian migration, and the collective understanding of the habits of migrating birds which could be used in conservation.

METHODS

Between the months of March and April in 2021, we conducted observational counts at the Blithedale and Corte Madera Ridge Junction. More specifically, we were located at the highest point of Corte Madera ridge twenty meters north of the junction of the Corte Madera and Blithedale ridges with a visual of the canyon and skies around the ridgeline. Beginning an hour after sunrise, we observed as many birds migrating north as possible, recording the species and position in relation to the ridge for a total of 3 hours each observation. Birds were either visually identified using 8 X 42 binoculars, or by flight call. Local birds were not included in the research. Observations were recorded in the eBird mobile app. We recorded the wind speed, wind direction, temperature, and cloud cover every hour using the windy and windfinder mobile apps and Weather.com. The process was repeated three times on days with northern winds and three times on days with southern winds. Using R Studio version 1.4.1106, we ran a two-way Anova with an interaction between wind direction and flight orientation to calculate their significance on the number of migrating birds observed.

RESULTS

We had 6 total count observations (3 northern winds, 3 southern winds) of migrating birds at the Blithedale and Corte Madera Ridge Junction in Marin County, California where we counted the number of birds flying along the ridge and their orientation (above or below) to the ridge. While neither wind direction nor the orientation to the ridgeline alone were significant in explaining the number of birds counted, there was a significant interaction between wind direction and orientation to the ridgeline (p-value<0.01, Table 1). The number of migrating birds counted at the ridgeline depended on both the wind direction and the orientation to the ridgeline. Therefore, wind direction had an effect on the number of birds counted above or below the ridgeline (with 84% of birds flying above the ridges with southern winds and 84% of birds flying below the ridge for northern winds (Figure 1).

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Wind direction	1	560.3	560.3	3.275	0.10793
Orientation to the ridgeline	1	120.3	120.3	0.703	0.42600
Wind direction:Orientation to the ridgeline	1	2296.3	2296.3	13.422	**0.00637***

Table 1: Results from a 2-way Anova with an interaction analyzing the effects wind direction and flight orientation to a ridgeline had on the number of migrating birds observed. Significance is noted by an asterisk and bolded.

DISCUSSION

I recorded the number of migrating birds above and below a heavily trafficked ridgeline to study the effect wind direction has on migrating bird behavior. Predicting that northern winds would influence birds to fly below the ridgeline and southern winds would lead to birds flying higher above the ridgeline, our hypothesis proved correct. The data showed that wind direction does in fact influence the altitude of migrating birds.

On days with southern winds, birds generally flew higher in altitude compared to days with northern winds where birds tended to fly lower, below the ridgeline (Figure 1). This may be due to birds optimizing efficiency and minimizing wind resistance (5). During southern winds, flying higher allows birds to take advantage of stronger tailwinds as they fly north (8). On the other hand, with northern headwinds, flying lower in more sheltered airways, such as a canyon, could decrease wind resistance migrating birds face, allowing them to save their energy for critical purposes, like escaping from predators. These results reveal more about how birds evaluate complex elements of their surroundings, including wind speed and direction, and the effects of the topography of a location on their flight, and use this information to their advantage.

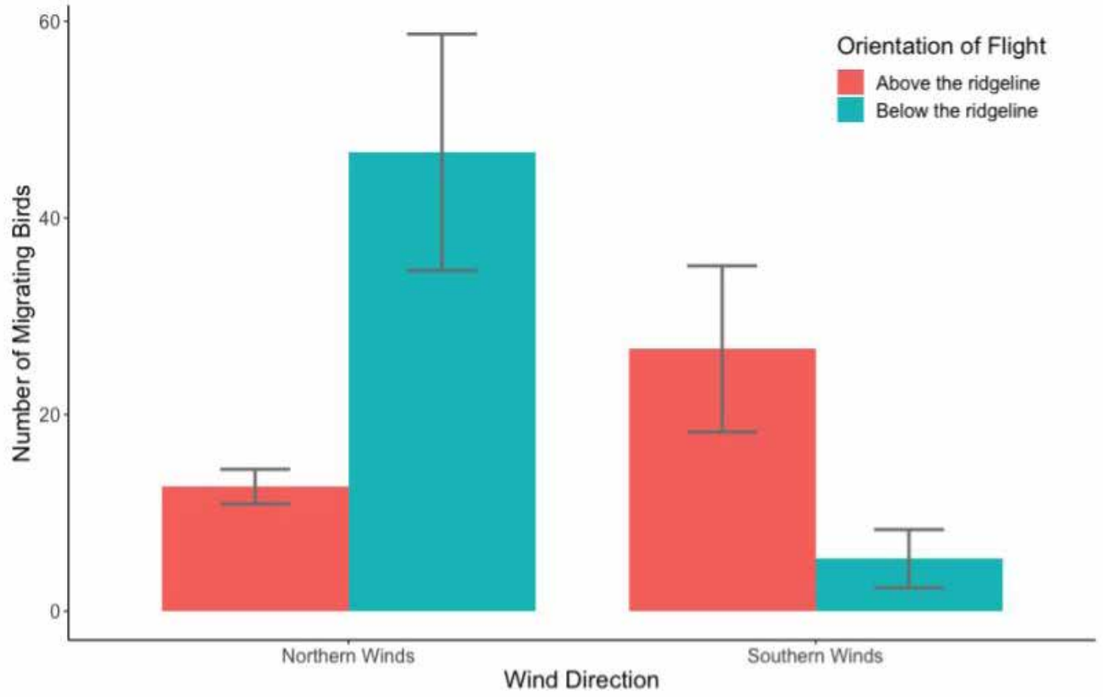

Figure 1: Flight orientation behavior of migratory birds above (red bar) and below (blue bar) the ridgeline at the Corte Madera and Blithedale Ridge Junction on days with northern winds and southern winds. Shown are means ± 1 SE.

During the experiment, I took note of variables that could bias the data collection. There were slight differences in temperature on the days that I collected data and differences in ease of visibility in that it is slightly easier to see birds when they are flying against the sky in comparison to the ridge on the other side of the canyon.

The results of this study may not directly aid conservation efforts, but it may prove helpful in other scientist's experiments, allowing them to gather more accurate and a greater quantity of data that can help to conserve migrating birds. This effect of converging ridgelines concentrating migrating birds is not only present in Marin County, meaning this experiment can be replicated across the globe. As migration offers many dangers ranging from increased predatory exposure, to fatal exhaustion, thirst, and starvation (6), discovering patterns and intricacies in their behavior is important so that they can be protected. Future questions brought up by this study could include how wind direction affects different species during migration. Larger birds tended to fly higher, so many of the birds flying above the ridge during northern winds were hawks or vultures whose size and strength allows them to fight the wind. It may prove interesting and useful to collect data on how wind direction as well as body mass affects the altitude of migrating birds.

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One of Isaiah Ferebee's study sites to compare water quality of different rivers in Maryland.