Abstract

For communities living near South Seattle's Lower Duwamish River, climate change adds a layer of complexity to current efforts to address the historic and ongoing environmental damage inflicted on the Duwamish Valley area by generations of settler-colonial and racist practices. Whether restoration projects being implemented in the area will buffer communities from climate change impacts is debatable, especially since the heavily urbanized and modified nature of the shoreline limits opportunities for restoration. In such places, novel ecosystem restoration techniques may be a way to expand options for improving ecosystem function and community health, but even practitioners of environmental restoration often have a narrow definition of the kinds of restoration that are desirable and successful.

Besides expanding people's understanding of restoration, might learning about novel ecosystem restoration techniques help make climate change more readily understandable? Could it also motivate and inspire people to take action on climate change? I aimed to answer that question by examining the attitudes and thoughts of study participants before and after information was communicated to them. Members of the Duwamish Valley community and other Seattle residents were presented information in an online workshop about the science of climate change, novel restoration techniques, and historic and ongoing environmental concerns for Duwamish Valley communities. Before and after the workshop, participants completed a survey in which they answered Likert scale statements and free-response questions.

Statistical analysis of the Likert scale responses and open coding analysis of the free-response questions revealed that participants' understanding of climate change impacts had significantly increased. Participants' receptiveness to the use of novel ecosystem restoration techniques also increased significantly. Participants displayed increased levels of motivation to take action on climate change, and they had also shifted from thinking about climate change in terms of its biophysical causes to thinking in terms of climate change's local impacts. Participants' ideas about what kinds of ecosystem restoration projects are possible and desirable had also broadened. Crucially, ideas on how to take action expanded after the workshop. Before, ideas were limited to low-effort modes of engagement with the political process; after, action-taking language more than tripled, with ideas expanding to include novel restoration ideas as well as community needs and priorities. I argue that climate change must be communicated within the framework of local impacts and novel restoration technique to best inspire and empower people to take action.

Introduction

Background

The heavily industrialized lower reaches of the Duwamish River, hereafter referred to as the Lower Duwamish River (LDR), was designated an EPA Superfund site about twenty years ago. The communities living in the area continue to be affected by the legacy of settler-colonialism and generations of subsequent damage to the environment and public health. Even before Superfund designation, the Duwamish Tribe and communities in South Seattle have worked and advocated to reverse or at least mitigate this damage by restoring portions of the riparian corridor and proximate areas.

Climate change presents an additional, daunting challenge to this work. A warming climate is projected to raise the LDR's water temperature, possibly to a point where conditions are too warm for threatened salmon populations (Hodgson et al., 2020; King County, 2015). Meanwhile, sea level rise and extreme weather events will impact ongoing restoration work, bring LDW waters into greater contact with polluted upland sediments, and increase the occurrence of combined sewer overflow events that release pollutants into the LDR (LDWG, 2019; King County, 2015).

Communities are increasingly feeling climate change impacts at these localized scales, and proactive decision makers and stakeholders involved in environmental stewardship are adjusting accordingly. Agencies involved in river cleanup—like the EPA, the City of Seattle, and King County—are thinking about how to adjust their restoration techniques and everyday practices to plan for climate change (LDWG, 2019).

For example, King County is adjusting its work, particularly its work in pollution source control, to reflect climate change concerns. Under an EPA grant-funded study to develop a stormwater retrofit plan for Water Resources Inventory Area (WRIA) 9, the county's Department of Natural Resources and Parks (DNRP) produced a report that assesses the potential impacts of climate change on rainfall volume, stream flashiness, and stormwater facility design. DNRP's report, which studied the majority of the Green-Duwamish watershed using different climate change scenarios, forecasted increases in the volume of water that would end up in stormwater ponds (King County, 2014).

In 2015, the county published a Strategic Climate Action Plan (SCAP). The SCAP is not specifically tailored for the LDR, but it lists several initiatives that would benefit the LDR, including a "ReTree King County" program that aims to plant a million trees along rivers in the county over five years. This program aims to restore lost riparian habitats, increase shade, and mitigate stream warming that could negatively impact salmon and other anadromous fish species throughout the Green-Duwamish watershed (King County, 2015). The county's 2018 blueprint for addressing climate change impacts on health quotes a community leader who is concerned about climate change negatively impacting water quality in the Duwamish (King County, 2018). This inclusion of community concerns is a vitally important step to ensuring not only that community members are heard, but that climate change impacts are made visible at the local level so that people who may be new to or skeptical of climate science can understand the urgency and saliency of the problem in their own communities.

Shoreline restoration efforts that are meant to expand tidally influenced wetland habitats and riparian zones often have a secondary purpose, which is to provide some measure of nature-based protection against the compounding impacts of climate change. These impacts include increases in sea level rise and in the frequency of extreme weather events like storm surges and floods. Community participation in such ecological restoration work also provides an opportunity to foster deeper connections between community and their environment, and to increase a sense of ownership and empowerment.

There are valid concerns as to whether local, small scale restoration projects can provide meaningful protection against future climate change impacts. For the LDR, however, the heavily industrialized nature of the shoreline makes conventional restoration projects (of the sort typically designed, implemented, and supported by settler scientists) impossible along much of the river's banks. Unless large-scale removal of hard-surfaced, urban infrastructure

was to become politically and economically feasible, opportunities for traditional restoration work along the lower Duwamish will remain severely limited, hampering the ability of the communities to respond nimbly to oncoming climate impacts (Hobbs et al., 2009).

In situations like these, novel ecosystem restoration techniques (NERTs) can be a way to creatively expand options for restoration along urbanized, concrete-lined shorelines. One such technique deployed in the LDR in the summers of 2019 and 2020 was an artificial "floating wetlands" project (Lee et al., 2021). Artificial floating wetlands, in which wetland plants are grown on a floating substrate, have been constructed for use in water treatment facilities as a natural method of improving poor water quality. The floating wetlands deployed over the course of two summers in the Duwamish were monitored to see if they would provide some of the functions of a natural ecosystem, sustain an aesthetically pleasing mix of plant and invertebrate species, and provide islands of new microhabitats for out-migrating juvenile salmon.

Installation of such floating wetlands is one example of a potentially viable alternative to conventional restoration efforts in places like the LDR; however, to date their uptake has been limited due to a lack of knowledge about such techniques and prevailing norms around shoreline restoration, as well as low receptiveness to placing more artificial structures into an already compromised environment. Community members may also prioritize other actions above experimental restoration techniques, particularly during the COVID-19 pandemic which has exacerbated existing societal inequities. Many of these inequities, such as displacement, increased risk of COVID-19 infection, and increased exposure to poor air quality, have clear connections to climate change, and many community advocates are articulating these connections themselves. However, in the short term, people who live in and advocate for the community have also articulated that topics like NERTs and creative ways to prepare for climate change may not be of immediate salience to Duwamish Valley residents (personal communications, 2020).

This project communicates the concept of NERTs to residents of the Duwamish Valley, who are from communities that are near the LDR. By doing so, I assess whether talking about NERTs helps to strengthen an audience's understanding of climate change impacts salient to their communities, and if talking about NERTs makes an audience more motivated and inspired to come up with creative community solutions in planning for climate change.

Relationship to Community

As a graduate student who is neither a South Seattle resident nor a member of one of the many underrepresented minority groups in the area, it was very clear to me that a power dynamic existed between myself and the community in which I was intending to conduct my research, and that I needed to practice reflexivity. Montana et al. (2020) provide multiple definitions of reflexivity, including but not limited to the examination one's own identity, intentions, and actions. Reflexivity can also mean analyzing the relationships that one fosters in the communities where they conduct their work.

While I was completing research for another project, I had important conversations with key informants who lived in and advocated for South Seattle communities. These informants were extremely critical of research in their communities that was designed and led by academia. They made it abundantly clear to myself and my colleagues that Duwamish Valley

communities are underserved despite being over-researched for their expertise, and that research conducted in their communities needed to be relevant to community priorities and provide adequate compensation for community members' time and knowledge to ensure that more people than just those who are conducting the research can receive tangible benefits (Lee et al., 2021). This feedback had a major influence on this study (cf. **Methods**).

Research Questions

Research Question 1 (RQ1): "Does learning about novel ecosystem restoration techniques change people's understanding of climate change impacts salient to their community?"

> **H_0:** Learning about novel ecosystems will not increase people's understanding of climate change impacts.
> **H_A:** Learning about novel ecosystems will increase people's understanding of climate change impacts.

Research Question 2 (RQ2): "Does learning about novel ecosystem restoration techniques make people any more or less receptive to the use of non-traditional restoration techniques?"

> **H_0:** Learning about novel ecosystems will not make people more receptive to the use of non-traditional restoration techniques.
> **H_A:** Learning about novel ecosystems will make people more receptive to the use of non-traditional restoration techniques.

Research Question 3 (RQ3): "Does learning about novel ecosystem restoration techniques change the level of motivation and inspiration people feel in taking action on climate change impacts salient to their community?"

> **H_0:** Learning about novel ecosystems will not increase the level of motivation and inspiration people feel in taking action on climate change impacts salient to their community.
> **H_A:** Learning about novel ecosystems will increase the level of motivation and inspiration people feel in taking action on climate change impacts salient to their community.

Methods

Communication Product

A detailed slide presentation (**Figure 1**) was designed to provide its audience with an overview of the science behind climate change, a history of the Duwamish River and the impacts of settler-colonialism on the river's ecosystem function. The presentation also described climate change impacts most likely to be experienced by residents of Washington State, and especially by communities near the Duwamish River. The presentation then described a novel ecosystem restoration project that I participated in on the Lower Duwamish

River, and ended with an overview of how ecosystem restoration projects can help communities become more able to withstand the impacts of climate change. After the event, a PDF file of the slide presentation was made publicly available on Github.

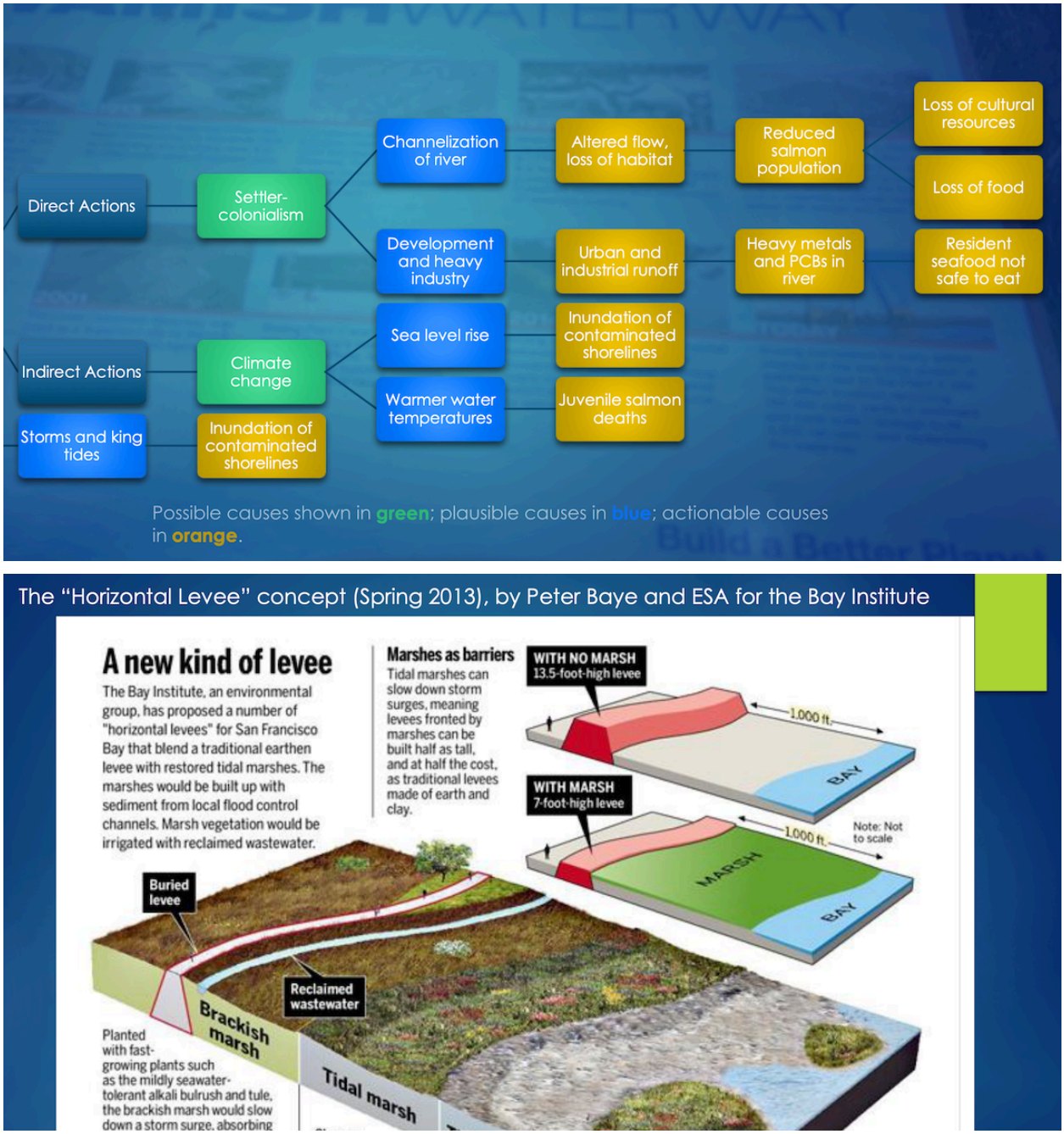


Figure 1. *Excerpts from Slide Presentation. One slide (top) presents a breakdown of causes for environmental concern in the Lower Duwamish River, while the other (bottom) discusses the concept of living shorelines as a model for restoration and climate adaptation.*

Audience for Communication

The identified audience was members of the Duwamish Valley community, broadly defined as residents of neighborhoods proximate to the LDR, such as residents of Beacon Hill, Delridge, Georgetown, and South Park.

Delivery of Product (Treatment)

The communication product was delivered in forty-five minutes during an online workshop event held on the Zoom online conference platform, followed by a ten-minute question and answer period. A few additional minutes at the end of the talk were used to encourage audience members to fill out a survey (see below) and to attend an upcoming in-person community science event in the Duwamish Valley.

To encourage attendance to the online workshop event by folks outside my immediate network and connections, multiple announcements were made about the event through social media posts, emailing of electronic flyers, and posting on free event websites and local news sites. 15 individuals attended the online workshop. All were Seattle residents at the time of the workshop and the majority were members of the Duwamish Valley community.

In recognition of the fact that Duwamish Valley communities are underserved despite being over-researched for their expertise, all Duwamish Valley participants were given a $25 honorarium for their time, while other participants were given $15.

Assessment of Communication

Two surveys (**Figure 2**) were administered to the online workshop audience to answer the three research questions (cf. **Introduction**) by determining any shifts in attitude before and after a treatment, which in this study was the online Zoom presentation event. The first survey was administered as part of the registration form used by attendees when signing up to join the presentation event, while the second was administered at the conclusion of the event.

Both surveys were virtually identical and presented the same nine Likert scale statements and the same three free-response questions (**Appendix A**). Of the 15 individuals who filled out the first survey and attended the online workshop, 13 also filled out the second survey (an 86.7% rate of complete participation). The target goal was for n to be greater than 10 ($n > 10$) for both surveys.

For the 13 individuals who filled out both surveys, response data from the Likert scale statements were analyzed in R/RStudio (**Appendix B**, or on Github) to quantify shifts in thinking before and after treatment. Three of the nine Likert scale statements met the Shapiro-Wilk test, implying that the distribution of the differences between two paired samples are not significantly different from the normal distribution. For these three statements, a paired two-sample t-test was conducted to see if the difference in attitudes before and after the survey were significantly different. For all nine Likert scale statements, a Wilcoxon signed-rank test was used to determine if the median attitude of the participants before the communication event was significantly different from the median attitude after the event.

Responses to the free-response questions were coded in Atlas.ti, a qualitative analysis software program, to identify themes and shifts in thinking. An open coding approach was used to minimize bias and to allow themes and frameworks to develop as a response to, and not in advance of, the survey data. Word clouds were generated to help identify themes and overall code structure. The codes were then applied to the answer to each free-response question and compared before and after treatment for shifts in opinion or overall outlook.

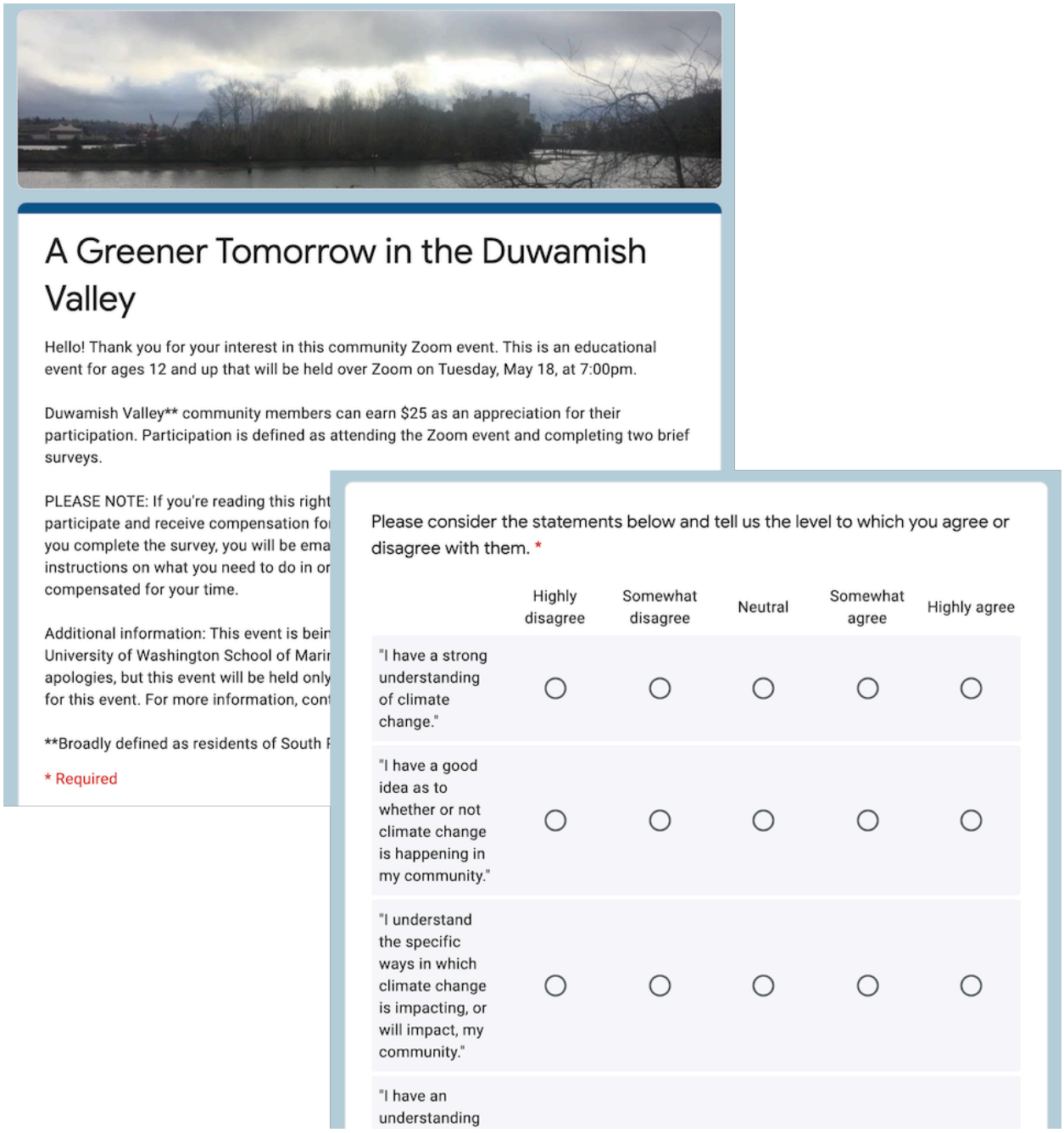


Figure 2. *Excerpts from Survey. Two snapshots of portions of the survey administered to participants before and after treatment. Aside from the instructions given to survey participants at the top of the form, the two surveys were essentially identical to each other.*

Community Advisors

Initially, the intent was to engage with community experts to help shape the research questions and the design of the survey and the slide presentation. However, based on the critical feedback myself and colleagues received about past work in the Duwamish Valley area from community members (Lee et al., 2021), I did not feel it was ethical to enlist a community member for hours of unpaid collaborative work when I could not adequately compensate them for their time. Instead, I chose to take on board the feedback I had already received from the community in my previous research and to use that to inform both the content of the presentation, the chosen audience for the presentation, and the mode of compensation for community members' time. I decided it was more important to spend all of the limited funds I had personally allocated for this study on direct compensation for participants.

Time Spent on Project

A total of 120 hours was spent on this project. A detailed estimate of time spent on different tasks is provided in **Appendix C**.

Results

Likert Scale Statements

Table 1 provides a summary of all nine Likert statements (S1 to S9), while **Table 2** presents the median values for participants' agreement with each statement before and after their experience with the online workshop. Median values increased for every Likert statement after treatment, and asterisks (**Table 2**) indicate Likert statements for which the Wilcoxon signed-rank test showed that the median agreement before treatment is significantly different from the median agreement after treatment.

S4, S5, and S9 passed the Shapiro-Wilk test, so a paired two-sample t-test was also conducted in addition to a Wilcoxon signed-rank test for these three statements. For all three Likert statements, both the t-test and the Wilcoxon signed-rank test showed a significant difference before and after treatment.

RQ1: Wilcoxon signed-rank testing of the three Likert scale statements designed for RQ1 (S1, S2, and S3) showed that the median values for S1 and S3 increased after treatment and that the difference in values before and after treatment was significantly different (**Table 2**). For both S1 and S3, the median increased from a value of 4 (somewhat agree) to 5 (highly agree).

RQ2: Wilcoxon signed-rank testing of the three Likert scale statements designed for RQ2 (S4, S5, and S6) showed that the median values for all three statements increased after treatment and that the difference in values before and after treatment was significantly different (**Table 2**). For S4, the median increased from a value of 3 (neutral) to 4 (somewhat agree). For S6, the median increased from a value of 4 (somewhat agree) to 5 (highly agree). S5 saw the largest increase in the median across all nine Likert scale statements, from a value of 2 (somewhat disagree) to 5 (highly agree).

RQ3: Wilcoxon signed-rank testing of the three Likert scale statements designed for RQ3 (S7, S8, and S9) showed that the median values for S9 increased after treatment and that the difference in values before and after treatment was significantly different (**Table 2**). The median increased from a value of 3 (neutral) to 4 (somewhat agree).

Table 1. *Summary of Likert Scale Statements*

	Statement
S1	I have a strong understanding of climate change.
S2	I have a good idea as to whether or not climate change is happening in my community.
S3	I understand the specific ways in which climate change is impacting, or will impact, my community.
S4	I have an understanding about ways I could protect myself and my community from climate impacts.
S5	I know where shoreline and creek restoration efforts in South Seattle are occurring at present, and why.
S6	I would like to see floating structures along the Duwamish River shoreline that create additional green spaces along the shore.
S7	The issue of climate change is important to me.
S8	I want to take action to prepare for the impacts of climate change.
S9	I know what specific actions my community can take to prepare for the impacts of climate change.

Table 2. *Participants' Median Agreement with Likert Statements*

Statement	**Before Workshop**	**After Workshop**
S1 *****	Somewhat agree (4)	Highly agree (5)
S2	Somewhat agree (4)	Highly agree (5)
S3 *****	Somewhat agree (4)	Highly agree (5)
S4 *****	Neutral (3)	Somewhat agree (4)
S5 *****	Somewhat disagree (2)	Highly agree (5)
S6 *****	Somewhat agree (4)	Highly agree (5)
S7	Highly agree (5)	Highly agree (5)
S8	Highly agree (5)	Highly agree (5)
S9 *****	Neutral (3)	Somewhat agree (4)

Free-response Questions

Table 3 provides a summary of all three open-ended response questions (FR1 to FR3), while **Table 4** provides the basic code structure that was constructed during analysis.

Table 3. *Summary of Free-response Questions*

	Free-response Question
FR1	Describe what you know or what comes to mind when you think about climate change.
FR2	Describe what you know or what comes to mind when you think about restoring or improving the environment.
FR3	Describe what you know or what comes to mind when you think about taking action on climate change.

Table 4. *Code Structure and Descriptions*

Code	**Description**	**Related Keywords**
Action	Action-oriented language on confronting and doing something about climate change.	Petition(s), political, protest(s), restoration, restore, restoring, solution(s).
Artificial	Language that describes something human-created.	Artificial, project(s), structure(s).
Causes	Language referring to the causes of climate change.	Carbon dioxide, emission(s), gas(es).
Community	Language about role of community in confronting climate change.	Community, local.
Impacts	Language referring to the impacts of climate change.	Flood(ing), impact(s), ocean acidification, sea level rise, temperature(s), warming.
Natural	Language that describes something non-human found in nature.	Natural, nature, plant(s), planting.

Table 5 provides the word clouds that were generated to inform the code structure. **Table 6** presents the number of times specific words that were related to a specific code appeared for all three questions before and after treatment.

Table 5. *Word Clouds. Created in Atlas.ti using free-response data. Common articles and prepositions (e.g. "the" and "of") were excluded from the analysis. Words that only occurred once or were a repeat of keywords used in the questions themselves were also excluded.*

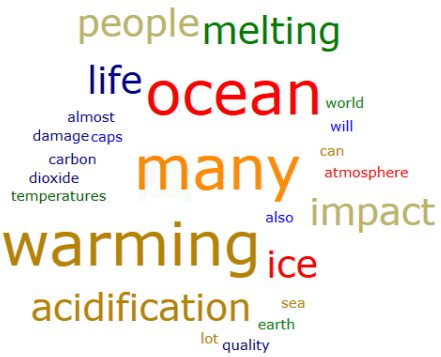
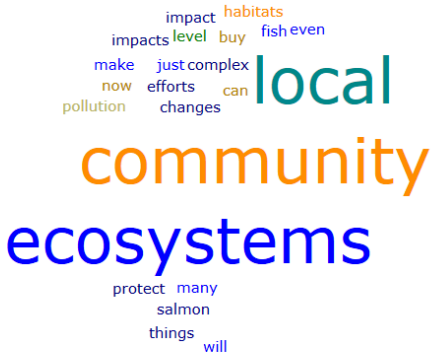
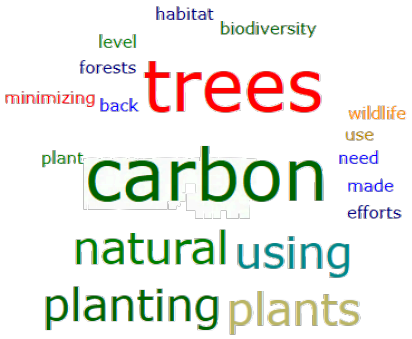
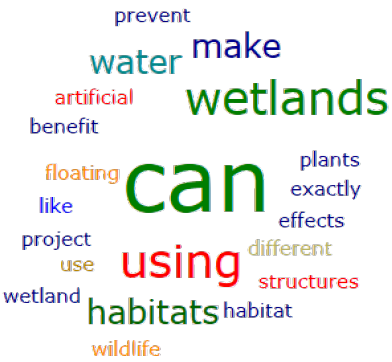
	Before Presentation	**After Presentation**
FR1		
FR2		
FR3		

Table 6. *Open Coding Results*

Statement	Before Workshop	After Workshop
FR1	causes (7) impacts (17)	community (6) impacts (8) action (2) causes (2)
FR2	natural (19)	artificial (9) natural (6) action (2)
FR3	action (6)	action (17) community (5) artificial (3)

RQ1: Before the treatment, participants mainly spoke in terms of the physical causes and impacts of climate change in answer to the free-response question about what they knew about climate change:

> "I know that humans are speeding up the process of global warming..." (Causes)
> "I think of greenhouse gases..." (Causes)
> "...melting of ice caps causing erosion, flooding, releasing large volumes of carbon dioxide..." (Impacts)
> "...droughts, natural disasters occurring in higher frequency and intensity..." (Impacts)

After the treatment, participants were still discussing the impacts of climate change but had shifted from talking about causes to talking about impacts at the local, community level:

> "I think more about the impacts to the community..." (Impacts, Community)
> "there are local adaptation efforts that should be taken to protect local ecosystems. While mitigation is important, it is not the entire solution." (Action, Community)
> "It really starts at the community level. The local population needs to be aware of what is going on..." (Community)
> "...droughts, natural disasters occurring in higher frequency and intensity..." (Impacts)

RQ2: Before the treatment, participants overwhelmingly spoke in terms of plants and growing more plants in answer to the free-response question about what they knew about restoration and improving the environment:

> "Replanting trees to mitigate damage of flood zones..." (Natural)
> "...mobilizing individuals to plant trees." (Natural)
> "...restoration in terms of planting more trees and other plants..." (Natural)
> I know about transplanting native plants." (Natural)

After the treatment, participants were still discussing natural ways to restore and improve environments but had shifted to a broader discussion of ways to restore the environment, such as through green infrastructure and other human-created designs, and more action-oriented statements were made:

> "...restoration involves research first and then implementation of different structures." (Artificial)
> "...we can make more effective and economical solutions available with some more innovation." (Action)
> "...intense collaboration needs to be done to generate a proper restoration project." (Artificial)
> "...it does not have to be creating a totally natural world. You can create artificial, smaller projects that still add greenery and benefit people." (Artificial, Natural)

RQ3: Before the treatment, participants mainly spoke in terms of engaging in political processes in answer to the free-response question about what they knew about taking action on climate change:

> "Creating awareness and canvassing for greener political interests and signing petitions." (Action)
> "Protests, signing petitions... we need to be quick and decisive in our actions." (Action)
> "I think about calling my representatives in Congress and lobbying them to support climate change legislation." (Action)
> "Protests, voting does not seem to work, holding corporations accountable." (Action)

After the treatment, participants were still sure of the importance of engaging in the political process, but had broadened their action-taking toolbox to include considerations of community needs and priorities, as well as the importance of preparing for climate change through human-designed projects. Accordingly, occurrences of action-taking language more than tripled after the treatment:

> "Paying attention to local government and voting for plans that increase biodiversity through restoration efforts that will take action on climate change." (Action, Community)
> "There are practical, meaningful ways that we can contribute to climate change solutions. These solutions do not have to do with the existential crises of contemplating a finite, warming planet. They have to do with addressing our personal, local and political avenues for change." (Action)
> "I think about restoring habitats, changing policies, and thinking of ways to get more funds for environmental issues and projects." (Action, Artificial)
> "...listening to a community and their concerns is important when wanting to enact change." (Community)

Discussion

RQ1: Since the median values for two of the three Likert scale statements associated with RQ1 were found to be significantly different before and after treatment, the data supports the alternative hypothesis (H_A) that learning about novel ecosystem restoration techniques increased people's understanding of climate change impacts. In particular, the significant increase in agreement for S3 ("I understand the specific ways in which climate change is impacting, or will impact, my community") presents strong support.

Coding analysis also supported the H_A by showing that after treatment, participants had shifted from talking about climate change in terms of its biophysical causes to talking about the fine-scaled impacts of climate change at a localized, community level.

RQ2: The median values for all three Likert scale statements associated with RQ2 were found to be significantly different before and after treatment, providing strong support for the alternative hypothesis (H_A) that learning about novel ecosystem restoration techniques increased people's receptiveness to the use of non-traditional restoration techniques. In particular, there was a noticeably large increase in agreement for S5 ("I know where shoreline and creek restoration efforts in South Seattle are occurring at present, and why").

While this increase on its own is not a surprise since a good portion of the presentation given to participants covered South Seattle's shoreline and creek restoration efforts, it provides some context as to why agreement with S4 and S6 increased after treatment. Coding analysis also supported the H_A by showing a clear shift and expansion in participants' thinking on the sorts of ecosystem restoration projects that are possible and desirable.

RQ3: Only one Likert scale statement associated with RQ3 had median values significantly different before and after treatment. S7 and S8 had high median values before and after treatment, which was perhaps due to selection bias in that only those who had some strong interest in climate change and its impacts would have participated in this study in the first place. Nevertheless, the significant increase in median value for S9 ("I know what specific actions my community can take to prepare for the impacts of climate change") provides some support for the alternative hypothesis (H_A) that learning about novel ecosystem restoration techniques increased the level of motivation and inspiration people feel in taking action on climate change impacts salient to their community.

Coding analysis also supported the H_A by showing that participants had broadened their action-taking toolbox beyond low-effort modes of engagement with the political process to considerations of community needs and priorities, as well as the importance of preparing for climate change through human-designed projects. This key finding is bolstered by the fact that occurrences of action-taking language more than tripled after the treatment—another result that supports the H_A.

Reflections on Outcomes

Residents of the Duwamish Valley are not unique in their ability to learn about climate change. However, they are distinct in that they are directly impacted by environmental inequities in ways that other communities in Seattle are not. Although there are some similarities among the participants in this project, it is likely that being aware of such impacts meant that Duwamish Valley community members were already more primed to understand the impacts of climate change. This assumption cannot be supported with the limited data available in this study, but it could serve as an interesting foundation for future studies on climate change communication.

Most of the main tasks I needed to complete in order to implement this study, such as research design, survey question preparation, data analysis, and synthesis were all carried out in a smooth, straightforward manner, and I believe that they were completed successfully. The main area identified for improvement are my outreach efforts:

As someone whose connections to community networks in the Duwamish Valley are still quite new and tenuous, it was difficult for me to attract a large number of participants to the presentation, even with the offer of compensation and weeks of advance notice. Also, events held in person, with the promise of not only compensation but also food and time to mingle with community, are also far more attractive and far more likely to attract participants than an online Zoom workshop, and that probably influenced the rate of participation as well.

I also either overestimated the effectiveness of online community event postings, or I was perhaps publicizing the event on platforms that were not salient to the communities I was targeting, despite the fact that those platforms had been effective for me in my past outreach work. For this reason, I ended up having to rely on personal, one-on-one outreach, which was extremely time-consuming and yielded minimal return for the effort expended. Researchers attempting to attract community members to studies of this nature should consider publicizing their events months, if not weeks in advance, and to do extensive research to see what online platforms or local news outlets are the best places for disseminating information about community events.

Conclusions

My results support the idea that targeted engagement and tailored communication about novel ecosystem restoration techniques can indeed not only improve people's knowledge of climate science and ecosystem restoration, but also broaden their thinking on climate change by making the science relevant to each community's unique contexts. It can also make people more receptive to creative, novel approaches to restoration, which will become ever more vital as the impacts of climate change continue to compound.

Presenting climate change through the lens of restoration and restoration techniques can shift people's thinking on climate change so that their attitude on the subject is more action-oriented, creative, and positive. Fostering these attitudes through effective communication tools will continue to be vital in ensuring community resiliency, and swift, novel, and effective action when it comes to climate change.

Climate change is urgent, but to confront it, change in the way science is conducted is also urgent. Students and other early-career researchers who aim to conduct this sort of work in communities, particularly in communities that are already over-researched and underserved, should practice reflexivity in multiple forms. This might mean reflecting on one's positionality and examining how a research project will benefit community members and be relevant to their interests and needs. At minimum, compensation should be offered to community members for their time, but ultimately researchers should be willing and ready to make commitments to the community that last beyond the timeframes of project dates and funding cycles if they are interested in building the sort of relationships necessary to communicate about climate change in a truly open, effective, salient, and wide-reaching manner.

Acknowledgments

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Appendix A – Pre- and Post-Event Survey

Question 1: "Does learning about novel ecosystem restoration techniques change people's understanding of climate change impacts salient to their community?"

S1. I have a strong understanding of climate change.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

S2. I have a good idea as to whether or not climate change is happening in my community.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

S3. I understand the specific ways in which climate change is impacting, or will impact, my community.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

Free-response: Describe what you know or think about when it comes to climate change.

Question 2: "Does learning about novel ecosystem restoration techniques make people any more or less receptive to the use of non-traditional restoration techniques?"

S4. I have an understanding about ways I could protect myself and my community from climate impacts.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

S5. I know where shoreline and creek restoration efforts in South Seattle are occurring at present, and why.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

S6. I would like to see floating structures along the Duwamish River shoreline that create additional green spaces along the shore.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

Free-response: Describe what you know or think about when it comes to restoring or improving the environment.

Question 3: "Does learning about novel ecosystem restoration techniques change the level of motivation and inspiration people feel in taking action on climate change impacts salient to their community?"

S7. The issue of climate change is important to me.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

S8. I want to take action to prepare for the impacts of climate change.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

S9. I know what specific actions my community can take to prepare for the impacts of climate change.

1 - Highly disagree
2 - Somewhat disagree
3 - Neutral
4 - Somewhat agree
5 - Highly agree

Free-response: Describe what you know or think about when it comes to taking action on climate change.

Appendix B – R/RStudio Code

```
# Load packages

library(here)
library(tidyverse)
library(ggpubr)

# Load and view data:

datalikert <- read_csv(here("data", "datalikert.csv"))
datalikert

# Compute medians and IQRs for each Likert statement:

datmedians <- t(datalikert %>%
  group_by(group) %>%
  summarise(
    count = n(),
    median1 = median(quest1, na.rm = TRUE),
    IQR1 = IQR(quest1, na.rm = TRUE),
    median2 = median(quest2, na.rm = TRUE),
    IQR2 = IQR(quest2, na.rm = TRUE),
    median3 = median(quest3, na.rm = TRUE),
    IQR3 = IQR(quest3, na.rm = TRUE),
    median4 = median(quest4, na.rm = TRUE),
    IQR4 = IQR(quest4, na.rm = TRUE),
    median5 = median(quest5, na.rm = TRUE),
    IQR5 = IQR(quest5, na.rm = TRUE),
    median6 = median(quest6, na.rm = TRUE),
    IQR6 = IQR(quest6, na.rm = TRUE),
    median7 = median(quest7, na.rm = TRUE),
    IQR7 = IQR(quest7, na.rm = TRUE),
    median8 = median(quest8, na.rm = TRUE),
    IQR8 = IQR(quest8, na.rm = TRUE),
    median9 = median(quest9, na.rm = TRUE),
    IQR9 = IQR(quest9, na.rm = TRUE)
  ))
datmedians <- datmedians[, c(2,1)]
datmedians

# Compute the differences:

d1 <- with(datalikert, quest1[group == "after"] - quest1[group == "before"])
```

```
d2 <- with(datalikert, quest2[group == "after"] - quest2[group == "before"])
d3 <- with(datalikert, quest3[group == "after"] - quest3[group == "before"])
d4 <- with(datalikert, quest4[group == "after"] - quest4[group == "before"])
d5 <- with(datalikert, quest5[group == "after"] - quest5[group == "before"])
d6 <- with(datalikert, quest6[group == "after"] - quest6[group == "before"])
d7 <- with(datalikert, quest7[group == "after"] - quest7[group == "before"])
d8 <- with(datalikert, quest8[group == "after"] - quest8[group == "before"])
d9 <- with(datalikert, quest9[group == "after"] - quest9[group == "before"])

# Shapiro-Wilk normality test for the differences:

shapiro.test(d1) ## p-value = 0.000116   ## Use Wilcoxon signed-rank test
shapiro.test(d2) ## p-value = 0.003767   ## Use Wilcoxon signed-rank test
shapiro.test(d3) ## p-value = 0.03487    ## Use Wilcoxon signed-rank test
shapiro.test(d4) ## p-value = 0.3826     ## Can use t-test
shapiro.test(d5) ## p-value = 0.1951     ## Can use t-test
shapiro.test(d6) ## p-value = 0.0005224  ## Use Wilcoxon signed-rank test
shapiro.test(d7) ## p-value = 4.025e-06  ## Use Wilcoxon signed-rank test
shapiro.test(d8) ## p-value = 0.002736   ## Use Wilcoxon signed-rank test
shapiro.test(d9) ## p-value = 0.1374     ## Can use t-test

# Compute t-tests where allowable:

ptt4 <- t.test(quest4 ~ group, data = datalikert, paired = TRUE)
ptt5 <- t.test(quest5 ~ group, data = datalikert, paired = TRUE)
ptt9 <- t.test(quest9 ~ group, data = datalikert, paired = TRUE)

ptt4   ## p-value = 0.005961  ## True difference in means is not equal to 0
ptt5   ## p-value = 0.0001305 ## True difference in means is not equal to 0
ptt9   ## p-value = 0.02117   ## True difference in means is not equal to 0

# Compute Wilcoxon signed-rank tests:

wsr1 <- wilcox.test(quest1 ~ group, data = datalikert, paired = TRUE)
wsr2 <- wilcox.test(quest2 ~ group, data = datalikert, paired = TRUE)
wsr3 <- wilcox.test(quest3 ~ group, data = datalikert, paired = TRUE)
wsr4 <- wilcox.test(quest4 ~ group, data = datalikert, paired = TRUE)
wsr5 <- wilcox.test(quest5 ~ group, data = datalikert, paired = TRUE)
wsr6 <- wilcox.test(quest6 ~ group, data = datalikert, paired = TRUE)
wsr7 <- wilcox.test(quest7 ~ group, data = datalikert, paired = TRUE)
wsr8 <- wilcox.test(quest8 ~ group, data = datalikert, paired = TRUE)
wsr9 <- wilcox.test(quest9 ~ group, data = datalikert, paired = TRUE)

wsr1   ## p-value = 0.03689   ## True location shift is not equal to 0
```

```
wsr2   ## p-value = 0.1294
wsr3   ## p-value = 0.01199   ## True location shift is not equal to 0
wsr4   ## p-value = 0.01214   ## True location shift is not equal to 0
wsr5   ## p-value = 0.003583  ## True location shift is not equal to 0
wsr6   ## p-value - 0.02627   ## True location shift is not equal to 0
wsr7   ## p-value = 0.3458
wsr8   ## p-value = 0.233
wsr9   ## p-value = 0.03301   ## True location shift is not equal to 0
```

Appendix C – Estimate of Time Spent on Project

Initial Conception (24 hours)

1. Background research (20 hours)
2. Project proposal (4 hours)

Climate Communication (23 hours)

1. Survey design, writing, and deployment (5 hours)
2. Preparation of slide presentation
    A. Background research (12 hours)
    B. Slide presentation (5 hours)
3. Communication event (1 hour)

Outreach (33 hours)

1. Flyer creation (1 hour)
2. Postings to community event calendars, local news websites, etc. (10 hours)
3. Personal outreach (16 hours)
4. Follow-up communications with participants post-event (4 hours)
5. Organizing payment for participants (2 hours)

Data Analysis (14 hours)

1. Statistical analysis of Likert scale data (4 hours)
2. Qualitative analysis of free response data (8 hours)
3. Additional synthesis (2 hours)

Production (26 hours)

1. Final report (24 hours)
2. Data management and publication on Github (2 hours)

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