Walking the Walk toward Increasing Access and Reducing Emissions: The Promise and Challenges of Virtual Climate Adaptation Convenings

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Abstract: Joint professional and stakeholder meetings to share local, regional and national responses to the current and projected effects of climate change have become regular, recurring events over the past decade. These "climate adaptation convenings" generally include presentations, discussions, and social learning about how to effectively respond to climate-related impacts. Many of these convenings shifted to virtual formats during the COVID-19 pandemic. We conducted a study to understand how four virtual convenings in the United States compare with otherwise similar in-person events. Through surveys with attendees of four virtual climate adaptation convenings, we explored how attendees' outcomes differed between conference formats and captured their perceptions of virtual vs. in-person events. Overall, 71% of attendees indicated that they were more likely or equally likely to attend future convenings online, and 62% reported that knowledge gain was about the same or better online than in-person. Many respondents appreciated the accessibility and more inclusive participation at virtual convenings, as well as the environmental benefits and reduced costs. However, interpersonal interactions were inferior in virtual formats, and some attendees experienced difficulties with technology and screen fatigue. Respondents shared suggestions for addressing these challenges. Altogether, findings suggest that virtual convenings have high potential if greater attention is paid to these elements.

Keywords: virtual conference; online networking; communities of practice; climate change adaptation; diverse perspectives; social learning

1. Introduction

Communities around the globe have been grappling with the climate crisis in the midst of a global coronavirus pandemic. Climate adaptation, which describes the process of adjusting to current or projected climate impacts to minimize negative effects or take advantage of potential benefits, [1] is commonly described as a "wicked problem". Wicked problems are socially and scientifically complex, involve a high degree of strategic uncertainty, and require the engagement of multiple stakeholders in collective action towards solutions [2–5]. Climate adaptation convenings bring scientists, practitioners and stakeholders together to address challenges such as flooding, sea level rise and wildfires. These conferences provide opportunities to acquire knowledge and resources that can be used to move action forward either independently or through building relationships that can lead to collaborative work toward solutions.

As a result of the COVID-19 pandemic, adaptation convenings shifted from in-person to virtual or hybrid formats in 2021. This created an opportunity for more inclusive participation due to reduced barriers such as time and costs of travel [6,7]. However, switching to a virtual format can constrain or change the nature of networking and social interactions, which may detract from social learning and other outcomes of value to

attendees [8,9]. The transition to virtual convenings created an opportunity to explore their effectiveness including in comparison to past in person events.

Gathering feedback from attendees on their learning and social experiences can improve future convenings [10]. In this multiple case study, we explored attendees' perceptions of four virtual climate adaptation convenings that occurred in 2021. We conducted a survey at each convening to understand who participated, their outcomes, their perceptions of virtual convenings compared with in-person convenings, and their recommendations for enhancing future virtual convenings.

1.1. Theoretical Framework: Social Learning Processes and Outcomes

Climate adaptation convenings typically involve diverse actors coming together across geographic regions to share ideas that can help agencies, organizations, communities and individuals to adapt to the local impacts of climate change. Such convenings can bring together Communities of Practice (CoPs), which are groups of people with a shared goal who deepen their knowledge and expertise through ongoing interaction [11–13]. Ideally, these convenings inspire social learning across attendees.

Reed and colleagues [14] (p. 7) define social learning "as a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks". Fernandez-Gimenez, Ballard, and Sturtevant [15] (p. 3) further clarify social learning in the natural resources context as "an intentional process of collective self-reflection through interaction and dialog among diverse participants stakeholders". CoPs can cultivate social learning by creating a conducive environment that allows people with different types of knowledge (e.g., local, traditional ecological, western scientific), perspectives and worldviews to share information, discuss ideas and explore solutions [14,16–18]. Kermish-Allen & Kastelein [19] (p. 14) suggest that online CoPs can provide opportunities for "a dynamic multi-directional process between participants" in which diverse forms of expertise and experiences can be shared".

Social learning within the context of climate adaptation convenings can produce a wide range of positive outcomes for participants, including both immediate and potential value. Immediate value includes what can be considered "proximal" outcomes, such as enjoyment, making new personal connections, feeling a sense of community in a challenging field, or learning new facts [20]. Potential value represents capital that could lead to future action, such as the strengthening of social relationships or networks, changes in attitudes or intentions, and the development of skills for future action [14,20]. We examined both the immediate and potential value of the climate adaptation convenings we studied. Social learning processes within these CoPs can also lead to future behavioral changes, active engagement in collective action and ultimately better management of ecological systems [14,16,18,21]. These more distal outcomes were beyond the scope of this study.

1.2. Benefits and Challenges of Virtual Convenings

Prior studies have documented multiple benefits of virtual conference formats. First, virtual convenings have a significantly lower carbon footprint than in-person events, due to the elimination of travel, lodging and consumable items [22–25]. Greenhouse gas emissions for a typical in-person conference goer range from 0.5 to 2 tons of carbon dioxide per attendee [7]. Virtual convenings are also typically more affordable than in-person events, often with lower registration costs and no travel associated costs [23].

Online conferences can increase access for members of many nondominant groups, including individuals outside of academia and government, such as local practitioners and community members [26–29]. In-person meetings are often cost prohibitive, and present challenges for those with disabilities or health problems [30], as well as for those who lack access to childcare [7] or other family care. A few recent virtual conferences have reported larger and more diverse audiences than previous in-person events [6,7]. For example, Davids and colleagues [31] found that more women, early career researchers, and

scientists from the Global South were able to attend an online conference than a face-to-face convening. Unfortunately, many studies often provide minimal or no information about who attended [9,32,33].

Understanding attendance is particularly important in the context of climate adaptation. Many groups (e.g., elderly, low-income, children, disabled, indigenous people, people of color) may be disproportionately affected by climate change due to existing vulnerabilities, such as socio-economic status, race/ethnicity, gender, age, cognitive and/or physical ability, historical and continuing injustices, etc. [34,35]. If adaptation planning processes fail to engage these groups, initiatives may reinforce existing social inequalities and exacerbate these vulnerabilities [36–38]. Virtual convenings are one way to open up learning and networking opportunities to many of these groups.

Fewer and less satisfying social interactions, technology difficulties, and screen fatigue are three key challenges associated with virtual convenings. Many people report that social interactions are not as valuable as in-person networking for attendees. Virtual conferences often lack networking opportunities like the impromptu meeting or coffee break discussions that occur during in-person conferences, and have fewer opportunities for meaningful discussions [8,9,31]. Additionally, technology challenges can hinder efforts to interact, network and participate in virtual meetings, although these challenges can be reduced with careful planning [39]. Bosslet and colleagues documented "screen fatigue" during a virtual conference, with respondents reporting that being in front of a screen for a long duration was difficult [8]. Higher levels of screen fatigue are associated with longer meetings, and this fatigue can lead to negative attitudes towards virtual meetings [40]. A final challenge involves internet accessibility, as some potential attendees may have difficulty attending due to a lack of consistent high quality internet access.

1.3. Interaction and Information Exchange in Virtual Environments

Technological innovations have created opportunities for better interaction and information exchange online. Attendees of online conferences appreciate the "chat" feature for posing questions and providing responses in real-time [8,41,42]. Harabor and Vallati found that an asynchronous discussion forum for attendees and speakers enabled the continuation of discussions after the presentations [32]. Polling and sharing documents online have also been identified as ways to enhance attendee engagement [8,23]. Prior suggestions to enhance networking at online convenings include: publishing an attendee list for ease of connection [43]; organizing speed meetups or matched one-on-one meetings [33,42] or "Chat roulette", where organizers randomly create small group breakout sessions [44]. Hybrid convenings, which involve some attendees meeting in-person and others online, can leverage all of these features to enable both in-person and virtual networking and learning. However, these are often expensive due to the need for both an online platform and a physical location [7].

1.4. The Present Study

In this study, we assessed attendee experiences in four online convenings focused on climate adaptation. The following research questions guided this study:

1. Who attended the online climate adaptation convenings, and to what extent did online convenings achieve positive outcomes for attendees?
2. How do attendees' perceptions of virtual and hybrid convenings compare with perceptions of past in-person convenings?
3. What recommendations do attendees have for future virtual climate adaptation convenings?

This mixed-methods study extends prior work by reporting participant demographics across four virtual convenings and evaluating a broad set of outcomes that are important for the field of sustainability science [14,20]. We also provide suggestions for future conferences based on participants' reflections about their prior experiences and preferences.

2. Methods

We conducted a mixed-methods multiple case study [45]. Four online climate conferences were selected based on the following criteria: a focus on climate adaptation; conveners' willingness to participate in research; and their timing (occurring between April and December of 2021). Key aspects of each of the four convenings are summarized in Table 1. We observed key elements of each conference (e.g., plenary sessions, interactive workshops, networking opportunities), and then conducted an online survey with attendees that included a mix of Likert-type scale items and open-ended questions. We first analyzed data for each case individually, reporting results to conference organizers to inform their planning for future convenings. We then synthesized and compared results across studies to address the study's research questions.

2.1. Procedures

We collaborated with conference planners for each of the virtual convenings to design surveys that served dual purposes; (1) to provide them with information to inform future planning, and (2) to provide our research team with data for a cross-case synthesis. Thus, each survey had some context-specific questions along with some more general questions that were useful across most or all conferences (see Appendix A). Likert-type scale survey items included four questions about attendees' backgrounds, 13 questions assessing outcomes, three questions comparing virtual and in-person formats for those who had attended both, and one question about format preferences for future convenings. The research protocol (#21-277) was approved by the Institutional Review Board at Virginia Tech. Conveners sent surveys on the last day of each conference, with two follow-up email reminders within one month. Respondents gave their informed consent for inclusion in this study prior to participation. Attendees were informed of the chance to be selected for $20 gift certificates as an incentive to complete the survey. A total of 493 responses were analyzed for this study.

2.1.1. Respondents' Backgrounds

Surveys included questions about attendees' employment sector, race and ethnicity, and years spent working in the field of climate adaptation. These questions were consistent across convenings.

2.1.2. Outcomes

We initially conceptualized outcomes using Wenger and colleagues' definitions of immediate and potential values [20] resulting from engagement within CoP's, as described above. We also considered prior research on the outcomes of climate adaptation convenings and other similar workshops [46]. These include measures of enjoyment, knowledge gain, relationship-building, and action orientation (intentions to act). Survey items measuring outcomes were identical across all convenings. Response options were provided on a five-point scale, ranging from strongly disagree to strongly agree. We performed an exploratory factor analysis to determine if these measures represented underlying latent variables to reduce the data into more meaningful overarching concepts. Because the study is focused on virtual experiences, we did not include scores for those who participated in-person at the hybrid conference ($n = 17$) when computing means.

2.1.3. Format Comparisons

Attendees were asked whether they had attended an earlier in-person version of the same convening in the past. Those who responded affirmatively were asked two follow-up questions to compare the virtual and in-person formats. All attendees were also asked: Would you be more likely to attend this conference again if it were online or in person? Response options were: 1—I'd **only** attend if online, 2—more likely to attend if online, 3—about the same likelihood, 4—more likely to attend if in-person, and 5- I'd **only** attend if in-person.

Table 1. Summary of Key Elements of Each Conference.

Descriptions of Convenings	Platforms	Activity Formats [1]	Number of Attendees (Survey Respondents)
11th Northwest Climate Conference, 6–8 April 2021 This conference has provided a networking and learning community for practitioners, scientists, tribal members, and community organizers interested in climate change impacts and adaptation in the Northwest for over a decade. The NWCC is committed to supporting equitable climate adaptation outcomes and building equity and diversity in climate science, policy, and adaptation practice. We encourage our conference attendees and presenters to advance the conversation around climate justice both as a stand-alone topic and across the many other topics and themes profiled in the conference.	Swapcard Wonder networking platform Zoom	• Plenary sessions • Traditional presentations • *Lightning talks with networking* • Yoga breaks • *Discussion board networking* • *Climate connections social* • *1:1 meetings* • *Mentoring sessions* • *Haiku networking*	417 logins (176)
2021 Carolinas Climate Resilience Conference, 10–12 May 2021 This hybrid conference, hosted by the Carolinas Integrated Science and Assessments (CISA) organization at the University of South Carolina, provided a place to share experiences and knowledge about opportunities, resources, and local initiatives across a range of professions and regional experts. Although research findings will be shared, this conference is intended to foster real-world solutions to climate adaptation in the Carolinas. All recorded sessions are archived on the CISA YouTube channel, and some of the networking activities are described in this CISA report.	Socio Wonder networking platform	• Pre-conference workshops • Plenary sessions • Symposia • Student poster presentations • Lightning talks • *Networking reception (in-person and virtual)* • *Coffee breaks with icebreaker questions* • *Video chats* via *Wonder* • *Virtual sponsor booths*	230 virtual (49) 93 in-person (17-not included in analyses)
At What Point Managed Retreat? Resilience, Relocation and Climate Justice 22–25 June 2021 This conference addressed a range of scientific, social, policy and governance issues around managed retreat (also known as strategic realignment and planned relocation). The conference, a major initiative of the Columbia Climate School and its Earth Institute brought together over 900 stakeholders from the public, private and nonprofit sectors, together with academics, scientists, and community representatives, to help develop a common understanding of this complex issue, and move the needle toward equitable solutions. A major emphasis was on issues of environmental justice, in recognition that the people most impacted by decisions around retreat have a key role in these conversations.	Cvent Discord channels ohyay	• Plenary sessions • Traditional presentations • Panel discussions • Flash presentations • Interactive workshops • *Discord discussion channels* • *Jazz networking event in NYC* • *Small group networking sessions*	850 registrants (196)
13th Annual Climate Leadership Summit 9–10, 2021 The summit is a regional event hosted by the Southeast Florida Regional Climate Change Compact to share knowledge, showcase climate action, engage leadership across sectors, and mobilize the collaboration needed to tackle this significant challenge at scale. The summit attracts innovative thinkers and leaders from the business, government, academic, and nonprofit community to exchange dialogue and ideas on expanding the region's capacity to respond to climate challenges and build climate resilience.	Cvent	• Keynotes • Panel presentations • Virtual exhibitor booth	529 logins, (72)

[1] Networking activities are italicized.

2.1.4. Attendee Experiences and Social Learning Processes

Open-ended questions elicited information about perceptions of virtual convenings, including strengths, limitations and key elements. While we would have preferred to keep these open-ended questions consistent across all convenings, conference organizers sometimes requested context-specific questions related to their goals. These questions, however, mostly solicited similar data (see Appendix A). For example, attendees at one convening were asked: "What would you have liked to hear more about at this conference? Was a perspective or voice missing or underrepresented?" This question was written by the conveners of the Managed Retreat conference, which included a broader and more international audience than the other three regional conferences. At those convenings, when attendees were asked about positive aspects of the conference as well as areas for improvement, many of their responses focused on new perspectives they appreciated, or missing perspectives from different sectors or backgrounds.

2.2. Data Analyses

2.2.1. Quantitative Analyses

We conducted a Principal Component Analysis using a Varimax rotation with Kaiser normalization to identify latent concepts in the outcomes data, using SPSS software. We created indexes for these constructs by calculating the mean score of all survey items contributing to each. To calculate overall statistics for reporting demographics and outcomes across convenings, we first calculated summary scores for each individual convening. We then equally weighted those percentages (in the case of demographics) or means (in the case of outcomes) to calculate an overall pooled mean score across all convenings. This eliminates the effect of unequal sample sizes for each convening. One of the convenings opted to not use several of the outcome questions related to social networking. Therefore, pooled means represented either a mean of three or four aggregated means, based on how many convenings used that question. We also report the range for each outcome (the lowest and highest outcome scores across all convenings). Comparisons between virtual and in-person conferences were summarized with frequencies of responses in each category. To compare differences across sectors in their format preferences, we conducted independent sample *t*-tests, and calculated Cohen's *d* values for indicators of effect sizes. Cohen's d scores of below 0.5 are considered small; from 0.5 to 0.8 are considered medium; and above 0.8 are considered large [47].

2.2.2. Qualitative Analyses

To answer research question 3, we used thematic analysis to analyze qualitative data from open-ended questions [48]. Responses were uploaded to Dedoose cloud-based analytic software. The first two authors reviewed all responses using an inductive approach to coding. While summarizing data for each case report, we discussed codes and definitions, and reviewed each other's codes, deliberating on discrepancies until we reached consensus. After writing case reports, we returned to the entire set of data to select broader themes that were most relevant to the cross-case synthesis. The final codebook included key themes representing respondents' experiences, with excerpts that represent each theme.

After identifying key themes, we conducted a member check by inviting conference planners from each group to join us for a virtual meeting. In this meeting, we shared our results, and then invited them to participate in a focus group. The focus group included individuals from 3 of the 4 convenings. We asked for their reflections on our results and interpretations of the data [48,49]. This final step of member checking broadly supported our initial interpretations and prompted us to include one additional code related to in-person regional networking after reviewing the data.

3. Results

Sample sizes for the results corresponding with research questions 1 and 2 are reported in Table 2.

Table 2. Sample Sizes for Likert-type Survey Questions.

Survey Questions	Sample Size
Socio-demographic characteristics	
Race/ethnicity	441
Employment sector	466
Time working in the field	476
Outcomes	
Social networking	414 [1]
Knowledge acquisition	488
Action orientation	484
Enjoyment	486
Satisfaction with content	480
Satisfaction with online platform	485
Comparisons between virtual and previous in-person formats	
Format preference	158
Networking opportunities	93 [2]
Amount learned	151
Thinking ahead to a future convening	
Likelihood of attending future convening based on format	430 [1]

[1] Sample sizes were smaller for these questions because they were not asked at the Climate Leadership Summit. [2] Only people who had attended previous in-person events responded to these questions; many had not attended networking events, so they did not respond to this question.

3.1. Socio-Demographic Characteristics of Respondents

Table 3 summarizes pooled means for responses to three questions about socio-demographic characteristics. For race and ethnicity and employment sectors, many respondents indicated more than one category.

3.2. Attendee Outcomes

Thirteen questions about outcomes were developed. Of those, ten were included in a principal component analysis (PCA) to explore factor structure. We computed satisfaction and enjoyment independently from other outcomes, as these items have their own inherent meaning and are useful for direct comparison on their own with other similar events. The PCA revealed three latent factors, explaining 75% of the total variance: Social Networking, Knowledge Acquisition, Action Orientation. Knowledge Acquisition represented immediate value, while Social Networking and Action Orientation included elements of both immediate and potential value associated with social learning with the CoPs [20]. Cronbach's alpha further confirmed the internal consistency of these three factors (0.87; 0.72, and 0.81, respectively). Internal consistency for each of the scales was examined using Cronbach's alpha: $\alpha = 0.87$ for social networking, 0.81 for action orientation, and 0.72 for learning. The factors were moderately correlated at $r = 0.63$ for learning and action orientation, $r = 0.34$ for social capital and learning, and $r = 0.40$ for action orientation and social capital.

Table 4 summarizes pooled means and standard deviation ranges for each construct and individual survey item across convenings. Items associated with satisfaction and enjoyment were reported as the most positive outcomes, followed by knowledge and resource gain, action orientation and expanded social networks.

Table 3. Socio-Demographic Characteristics of Survey Respondents.

Descriptor	Pooled Mean Percentage	Range between Conferences
Race and Ethnicity of Respondents (Which of the following categories best describes you? Check all that apply).		
White/Caucasian	76%	68–80%
Asian or Asian American	6%	0–12%
Hispanic or Latinx	6%	2–8%
Black or African American	6%	2–10%
Native American or Alaskan Native	1%	0–3%
Native Hawaiian or other Pacific Islander	1%	0–2%
Employment Sector (In what sectors do you work? Check all that apply).		
Academia	29%	6–42%
Local government	22%	8–44%
Nonprofit	18%	10–26%
State government	12%	1–19%
For profit or private sector	9%	5–18%
Federal government	7%	0–14%
Community group	3%	0–8%
Tribal government	3%	0–8%
Time working in field (How long have you been working in or adjacent to the field of climate adaptation?)		
0–2 years	21%	11–29%
3–5 years	27%	23–29%
6–9 years	18%	13–19%
10–15 years	17%	13–19%
More than 15 years	16%	11–16%

Note: Frequencies for each conference were aggregated; a weighted mean is reported to reflect the average frequency across four conferences. Range between conferences includes the lowest and highest percentages reported at any of the four convenings. 7% of respondents did not indicate a race/ethnicity, 6% did not indicate a sector, and 3% did not indicate their time spent working in the field.

3.3. Comparisons between Virtual and In-Person Formats

Attendees were asked whether they had attended a prior in-person convening of this particular conference. The 158 who responded yes were asked to compare their virtual and in-person experiences (Table 5). Overall, 64% of respondents indicated a strong or slight preference for an earlier in-person convening that they had attended.

Table 6 compares learning and networking opportunities for individuals who attended both formats. The majority of those who attended networking sessions indicated that networking opportunities for online convenings were worse or slightly worse than in-person. However, most felt that they learned about as much online as they did in person.

3.4. Likelihood of Attendance Based on Format

Participants at three of the convenings (excluding the hybrid Carolinas Climate Resilience Conference) were asked about their preferences for future convenings. Out of 430 respondents from these three groups, 29% indicated that they were more likely to attend the next conference if it were online; 42% indicated that they were equally likely to attend either format, and 20% were more likely to only attend if in-person. 6% indicated that they would only attend if online, while only 3% reported that they would only attend if in-person (see Figure 1).

Table 4. Reported Outcomes for Online Climate Adaptation Conferences. All items measured on a 1-to-5 scale, ranging from strongly disagree (1) to strongly agree (5), except for two of the satisfaction and enjoyment items (marked with an asterisk) for which the scale was comprised of the following five response choices: Very dissatisfied (1), Dissatisfied (2), Neither satisfied nor dissatisfied (3), Satisfied (4), Very satisfied (5).

Outcome	Pooled Mean	Range (Lowest to Highest Mean for Any Convening)	# of Convenings That Assessed This Outcome
Social Networking	3.31	3.18–3.58	3 [1]
After attending this conference, I intend to collaborate with people I met on future climate projects	3.55	3.23–3.94	4
I met other participants that I hope to collaborate with in the future	3.36	3.19–3.58	3
I had meaningful interactions with other people	3.28	3.07–3.64	3
I made new connections with other participants	3.19	2.98–3.40	3
Knowledge Acquisition	4.03	3.76–4.21	4
I acquired new knowledge	4.13	3.83–4.33	4
I learned about resources and/or tools that will be helpful in my work	3.93	3.68–4.20	4
Action Orientation	3.81	3.67–4.06	4
I intend to apply something I learned at the conference in my work	3.97	3.76–4.18	4
I intend to use resources that I was introduced to	3.82	3.68–4.20	4
I intend to implement an idea or suggestion	3.65	3.49–3.90	4
Satisfaction and Enjoyment [2]			
I enjoyed participating	4.14	3.99–4.29	4
Satisfaction with content presented *	4.27	4.06–4.57	4
Satisfaction with online platform *	4.26	4.21–4.35	4

[1] A pooled mean was not computed for one of the convenings where the post-conference survey did not include most of the social networking questions as their convening did not include many opportunities for social interactions. [2] Satisfaction and enjoyment are distinct outcomes (Cronbach's alpha = 0.58); thus a composite mean score is not reported for these three items.

Table 5. Format Preferences for Respondents who Attended Prior In-Person Conferences.

Preference	% of Respondents
Strongly prefer in-person	38%
Slightly prefer in-person	26%
No preference	10%
Slightly prefer online	17%
Strongly prefer online	9%

Table 6. Comparing Networking and Learning Opportunities in Different Formats.

Format Comparisons	Networking Opportunities [1] (n = 93)	Amount I Learned (n = 151)
Reflecting on your participation in both the online and in-person formats of this conference, please indicate your level of preference.		
Online was much worse than in-person	57%	9%
Online was slightly worse compared with in-person	29%	29%
Online was about the same as in-person	10%	42%
Online was slightly better than in-person	3%	11%
Online was much better than in-person	1%	9%

[1] Participants were asked to compare networking opportunities only if they had attended networking sessions in both formats. Thus, the sample size is smaller for this question than the more general question about learning.
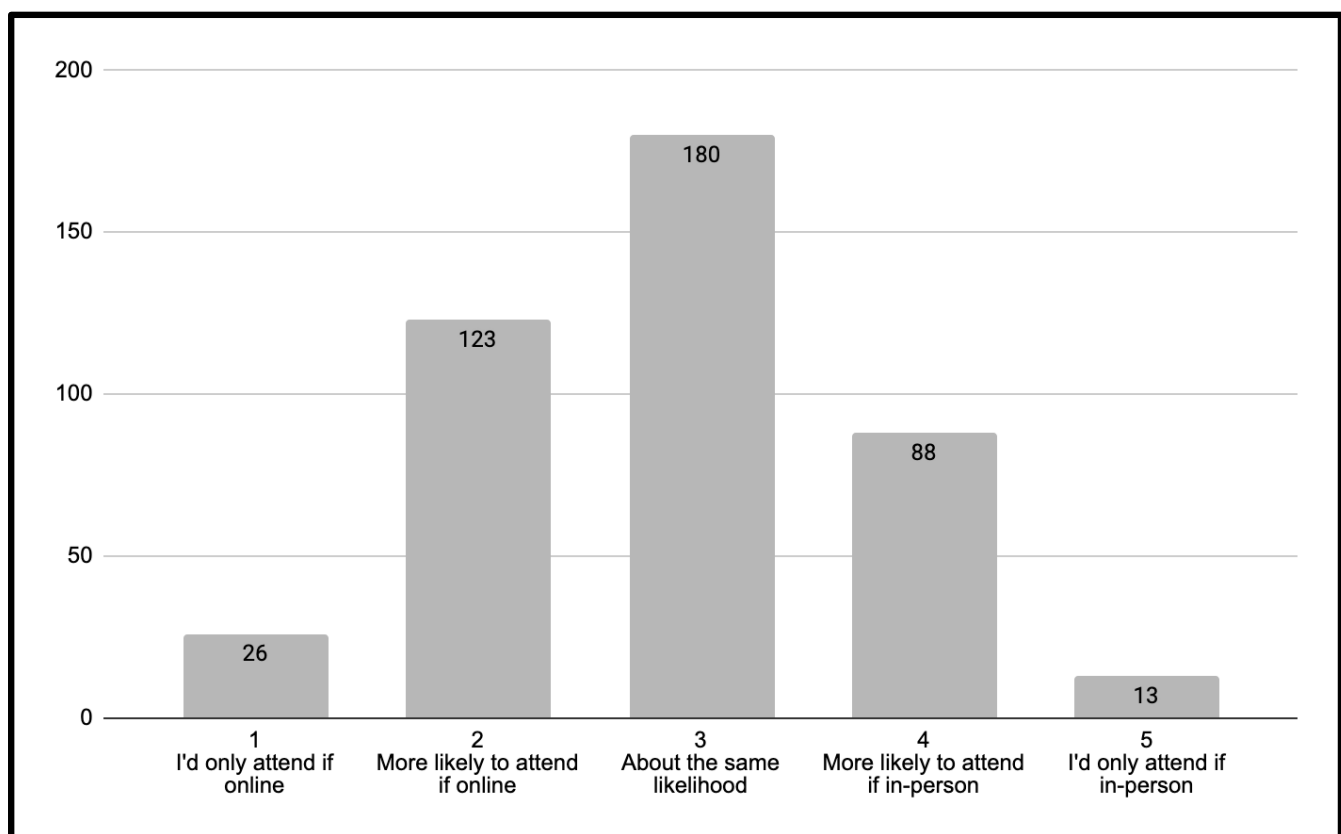
Figure 1. Likelihood of attending this conference again based on format.

We observed some differences between the groups that attendees represented. Figure 2 displays the mean differences for the most common types of attendees in the sample. Community groups and federal government employees were significantly more likely to indicate a preference for attending future convenings online ($p < 0.05$, Cohen's $d = 0.5$ and 0.38, respectively). For-profit and academic sectors were significantly more likely to report a preference for attending in-person events, though with smaller effect sizes ($p < 0.05$, Cohen's d = 0.37 and 0.21, respectively). Native American or Alaskan Native respondents ($n = 8$) were the only racial or ethnic group that had a significantly different response than the whole group mean for this question. This group expressed the strongest preference for attending online (mean = 2.13; $p < 0.05$). Despite the small sample size, the effect size was large for this group (Cohen's $d = 0.82$).
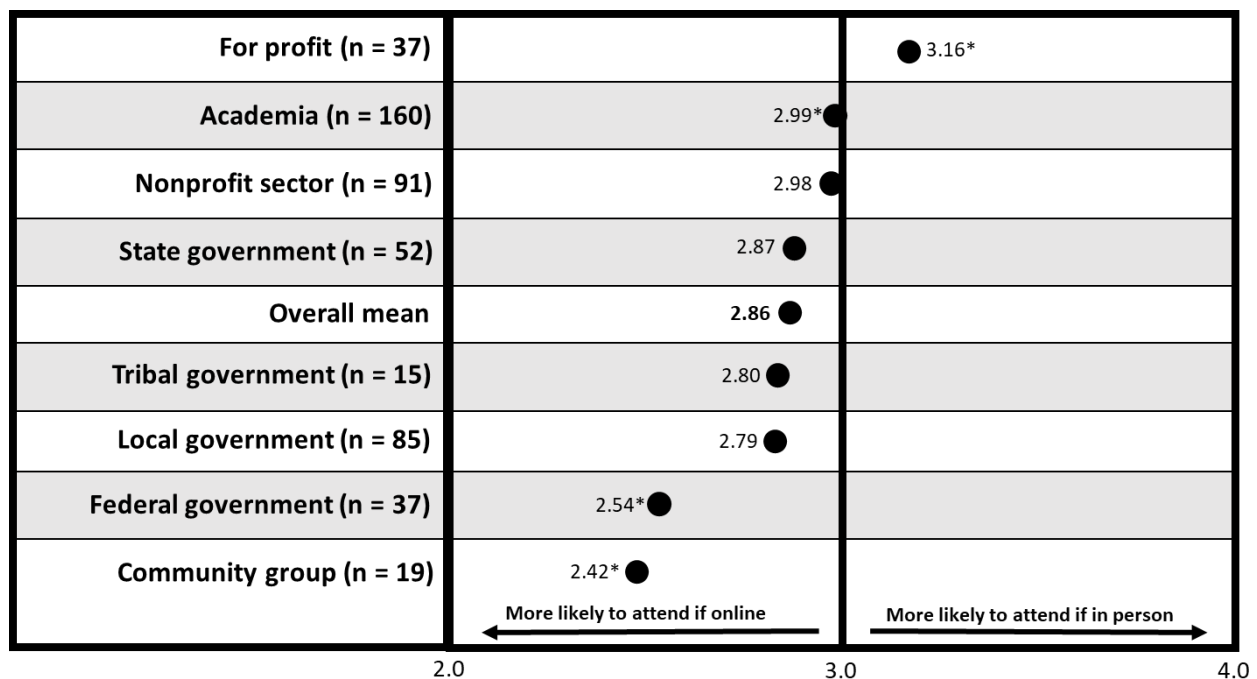
Figure 2. Differences by sector in likelihood of attending this conference again based on format. Asterisks indicate a statistically significant difference ($p < 0.05$) from the mean. Not all categories were mutually exclusive (some individuals selected more than one group).

3.5. Benefits of Virtual Convenings

Many attendees reported appreciating the increased accessibility (e.g., affordability, health/safety, inclusivity and availability of recorded sessions) of online conferences and the broader level of participation which sparked new insights and perspectives. They also noted the value of recorded sessions for later viewing and the lower carbon footprint of virtual convenings.

3.5.1. Increased Accessibility and More Inclusive Participation

Respondents commented that the virtual format increased access for parents, people with disabilities, and individuals with financial constraints. One respondent wrote, "virtual is much more accessible, since costs and travel are reduced and it seems like virtual could help a lot of folks who need different accommodations". Another explained, "As a mother with several small children, traveling away from home for conferences is much too challenging so I don't. Online platform makes it possible for me to participate in this important conference". With regard to affordability, one respondent noted, "I don't know what the cost of an in-person conference would be, but between the conference and travel, it would probably become inaccessible for me. In contrast, $40 was quite reasonable and enabled me to attend whether or not I could be reimbursed by my office". One attendee mentioned other benefits as well: "Less fatigue (for someone with a walking disability) and easier to follow the talk in front of my laptop (less disturbances) and easier to take notes". Respondents also appreciated the fact that they could stay home and avoid COVID-19 exposure by attending online.

Several people expressed appreciation for the broader participation that the virtual format provided. "I liked that the online conference increased access. That would be my biggest priority for future conferences, whether it's having online portions to get the info to more people, or lowering attendance costs and paying speakers so more people especially from marginalized groups can attend". Another respondent mentioned that they appreciated "the wide range of expertise at all levels of government and community that were brought together . . . I believe the online format made this possible since a number of

our keynotes and panelists would not have been able to participate if they had to travel and stay in hotels".

3.5.2. Gaining New Insights and Perspectives

Overall, the data reflected a common belief that the virtual format enabled more diverse participation, and that this participation enhanced each experience. Multiple respondents across all four convenings expressed an appreciation for the variety of perspectives included, particularly at the two larger convenings. For example, one respondent wrote, "The diversity of speakers allowed for a large range of thoughts/ideas on how to approach retreat which was very interesting". Similarly, another person said, "I appreciate the depth of thought, the knowledge, and the diversity of the participants. It provided me with a broader perspective and a greater sense of hope". Another attendee commented, "From what I saw, it seemed like there was an effort to include many voices that have historically been left out of the academic conversation, and I hope this effort will continue. Hearing stories from community members who are experiencing the challenges is particularly valuable".

Several attendees mentioned gaining a broader or new perspective from a particular presentation. For example, a respondent wrote, "One thing that stood out was Queen Quet speaking for 5 min in Gullah Geechee and then explaining that's what scientists talking science sounds like to most people (i.e., hard to understand). As a scientist, I needed to understand that point of view". Another respondent wrote the following, "I also really appreciated the clear effort to center BIPOC [Black, Indigenous, and People of Color] activists, leaders, and practitioners in many of the conversations. I particularly enjoyed the panel led by Indigenous women academics and learned a ton from their conversation and presentations. Having a variety of perspectives and approaches on each panel was also useful (as opposed to grouped by affinity), as it generated more debate and demonstrated a wider range of considerations".

When identifying specific perspectives, respondents most commonly noted the value of indigenous and youth perspectives. One participant wrote, "I really enjoyed hearing Tribal and community perspectives and the issues about language and cultural values that these presentations raised and brought to my attention". Another explained, "It's important to hear what tribal leaders have to say about this hugely important topic, and they set the tone with their wisdom, honesty and humility". With regard to youth perspectives, several people mentioned feelings of hopefulness after listening to their presentations, e.g., "I especially thank you for including the youth panel . . . mostly because they bring me personally, so much hope and a way to breath". Another reported, "The youth panel were so well prepared and well spoken. I learned so much from them. They modelled what I want to be when I grow up".

3.5.3. Lower Carbon Footprint

Many respondents explicitly mentioned the lower carbon footprint from a virtual convening. One wrote, "I believe if we want to stay true to the conference and its purpose, online is the way to go to keep carbon footprint low". Most of these comments came from one convening, where attendees were repeatedly informed about the greenhouse gas emissions reduction in the virtual format and received information about their collective carbon savings after the convening (see Figure 3).

Figure 3. "UnCarbon calculator" summary as presented to participants at the 11th.Northwest Climate Conference.

3.5.4. Access to Recorded Sessions for Continued Learning

Many attendees from two of the convenings commented on the value of access to recordings of sessions. One respondent wrote, "I appreciated that we were able to go back on our own time and watch the seminars that we were not able to attend live. This maximized the impact of the conference". Another wrote, "what I also really appreciate about online conferences is that all of the sessions are recorded on zoom, and it's a huge benefit to be able to watch them again or see those that I missed. I watched the recordings from 2019 but I think that the online format is better for recordings".

3.6. Challenges with Virtual Convenings

Respondents identified suboptimal networking, technology barriers, and screen fatigue as limitations of online conferences.

3.6.1. Suboptimal Networking

Most respondents who expressed a desire for in-person attendance cited challenges with networking as a reason for their preference. Respondents described networking in-person as more unplanned and natural, allowing for more serendipitous meetings and

exchanges and easier follow-up conversations with speakers. One respondent wrote, "Nothing really substitutes for face-to-face interactions for developing relationships". Respondents described virtual networking as lacking spontaneity. Additionally, many admitted that they did not attend any networking events. One explained, "I appreciate the efforts made to provide the spaces/opportunities for virtual networking and wish that I had taken advantage of them!" For those that did attend specific networking components, many were disappointed about the lack of participation. One respondent wrote, "It felt like the networking sessions I was in were often really small and mostly had great but very new-to-the-field grad student participants".

3.6.2. Technology Barriers

Some attendees reported having difficulty with technology, ranging from general problems to problems with specific platforms. For example, one attendee wrote, "Being tech challenged, the one area I did have some issues with was joining the live sessions for some reason the join button didn't always appear". Others mentioned challenges transitioning between different platforms for networking. One wrote, for example, "Wonder platform was problematic for me (seemed to take more bandwidth than the main platform and I was participating from a rural area with low connectivity)". Additionally, many attendees reported challenges interacting with others during sessions. One presenter noted, "Everything went well using zoom, but it was really hard to understand how many people were in the room and what my audience was, which was a bit awkward".

3.6.3. Screen Fatigue

Respondents reported that they were fatigued or unable to focus when there were too many consecutive sessions or hours without a break. One explained, "Three days without a lot of breaks was really overwhelming and at times made it very hard to focus". Another attendee reported, "being online all day is really difficult. We all stepped away when we needed to but it made it feel like you had to choose between missing out and giving your eyes a break from the screen". One attendee recommended, "Less presentations and events packed into one day. Too long to be at a computer or even an in person conference event".

3.7. Benefits and Challenges of the Hybrid Convening

In hybrid convenings, attendees have a choice in formats. One attendee summarized this benefit well, "the energy that occurs when the summit is in person is priceless, but the efficiency provided by online format is excellent. When conditions allow, best to have both in-person and online options". One challenge with the hybrid conference was difficulty communicating across contexts. For example, those who were in-person found it challenging to use the Socio platform to ask questions of in-person speaker., e.g., "I think if I had to change one thing would be to have in-person attendees ask their questions 'live' vs. through the app, that felt a little cold and odd.. and I didn't like being on my phone while someone was speaking so that I could ask a question". The same challenge occurred between in-person attendees and virtual presenters. One in-person attendee wrote, "I appreciated being able to interact with those who weren't able to attend in person, but it was awkward and sometimes frustrating to interact with the virtual presenters as an in-person attendee during the Q&A portion of the sessions". A second factor to consider in hybrid convenings is cost; the hybrid conference had the highest cost for attendees. One conference planner mentioned that hybrid convenings are expensive because of the need to purchase an online platform in addition to renting space for in-person attendees.

3.8. Suggestions for Future Virtual Convenings

Respondents reflected on their experiences and made suggestions about structuring the schedule and creating opportunities for better discussions and networking.

3.8.1. Curate Conference Sessions to Avoid Burnout

Several suggestions emerged related to scheduling. People suggested shorter days with fewer simultaneous talks or sessions and more frequent breaks. Comments were particularly acute from attendees who attended a convening with some 12 h days, e.g., "It was a dense and long conference, 12–13 h of zoom meetings with little breaks—maybe a bit much. I was exhausted . . . let's think of stretching it out if we do it again online. One attendee wrote, "There was so much (great) content that it was almost hard to absorb, particularly given the difficult nature of the topic. Maybe less/shorter sessions would be more impactful". Some attendees suggested more careful curation of topics as well to avoid repetition in content or hearing from the same people several times. Many wanted built-in breaks, e.g., "It would have been helpful to have some short breaks throughout the conference days, like you would have between sessions at an in-person conference. Similarly, one attendee wrote, "I burned out really quickly with the fully online conference format. Three days without a lot of breaks was really overwhelming and at times made it very hard to focus", suggesting the need for breaks to avoid screen fatigue.

3.8.2. Create Opportunities for More Discussion

People expressed a desire to interact and exchange ideas throughout (and after) presentations. One explained, "I appreciated the chat options for people to ask questions and have dialogue during the conference sessions. It enabled people to have peer-to-peer exchange instead of limiting to just speaker-attendee engagement". Another person wrote, "for me the main point of attending a conference is to network with colleagues in person or have meaningful discussions with presenters after their presentations. I would say, leave the session rooms open for a half hour or so after the session ends to facilitate the spontaneous discussions that normally happen". Another attendee wanted more room for discussion to "debrief with folks and process with other practitioners". Many respondents echoed this sentiment, desiring opportunities to reflect, exchange ideas, and ask and answer questions about concepts presented during sessions. Several respondents suggested creating breakout rooms for small group discussions and reflections after a presentation. Another noted, "I would have liked to see more networking opportunities integrated into the regular sessions, instead of only existing as separate sessions".

To build in more time for discussion, one attendee suggested pre-recording sessions and planning synchronous discussions during the conference, similar to a hybrid college course, "For future online content, please consider a mix of synchronous (live) and asynchronous (recorded) content. It should be possible for speakers to record their presentations ahead, attendees can pick and choose which to watch, and then attend scheduled live Q&A sessions".

3.8.3. Offer Varied Networking Opportunities

People appreciated having a variety of networking opportunities, such as small group virtual sessions with guiding questions and mentoring sessions. They shared additional ideas for regional in-person events and easy ways to follow up with people they met. A variety of networking activity formats were suggested. One respondent suggested, "provide spaces for meeting new people with icebreaker questions". Another "thought the platform used had potential but it may have worked to even just have small breakout rooms with 'get to know you' questions". Small group sessions with guiding questions occurred at several of the convenings and were generally appreciated by attendees. Two attendees also noted the value of mentoring sessions, e.g., "I really enjoyed the mentorship sessions because everyone I talked to was engaging and open to conversations".

Many expressed the value of connecting with others in-person in addition to virtual networking. Some suggestions for creating or enhancing these opportunities included:

- "Excursions or field trips to visit project sites/meet people locally".
- "Have regional hosts for a single day".

- "Maybe there could be local hubs where smaller groups in each city could call in from, so that you minimize travel but keep an aspect of the in-person collaboration".
- "Arrange a few in-person social get-togethers with a good plenary speaker . . . The speaker could be streamed for an online audience as well".

One attendee suggested, "to address concerns about lack of attendance at networking events, people may need reminders about the value of these events". For example, at the start of one conference, an organizer mentioned that the conveners had done their best to make the virtual conference as close as possible to the real thing, and encouraged attendees to intentionally engage in networking opportunities to improve the conference for everyone.

3.8.4. Ease of Follow-up and Better Visibility

Respondents noted that ease of contact was critical to be able to meet and follow up with personal connections they made. This included being able to schedule a video chat or to easily find contact information to set up a later meeting. One respondent appreciated how Swapcard has an open video chat option built into its messaging feature. Another attendee mentioned that "it was very easy to message people (in Swapcard). There was a bit of a learning curve to figure it out, but once I did it was easy to navigate and use".

Respondents also wanted to see who else was attending a particular session, either seeing their faces via video or just seeing names and affiliations in the discussions or chats. One respondent wrote, "I strongly encourage some way of allowing attendees to see who else is in the audience. I found that not being able to see who else was in a given session impeded my ability to connect with other participants".

4. Discussion

We compared online events to past in- person convenings of the same conference in previous years and assessed format preferences for subsequent years. While nearly two-thirds of respondents who had attended both formats expressed a preference for prior in-person convenings, 35% of virtual convening attendees expressed a greater likelihood of attending the next convening if it were online. This was especially the case for federal government employees and community groups. Another 42% reported no preference in format for future attendance. More than half (62%) suggested that the amount they learned in their virtual convening was about the same as (42%) or even better than (20%) prior in-person convenings. However, 86% noted that networking opportunities were not as good online when compared to in-person settings. Other challenges of the virtual convenings were similar to those found in prior studies, including screen fatigue, technology issues, and insufficient opportunities for high-quality interpersonal interactions [8,9,39,40]. Taken together, the findings suggest a high potential for learning, diversifying attendance, lowering greenhouse gas emissions, and reducing costs, as well as a strong desire to enhance social networking opportunities at future virtual convenings. We discuss the key findings in light of these overarching insights.

4.1. The Benefits of Virtual Convenings

Throughout the pandemic, virtual climate adaptation convenings have offered a way for collaboration and learning to continue, as well as to include a broader set of participants. Our results confirm prior work that individuals from marginalized groups are more likely to attend virtual events, and may be unable to participate in conventional in-person convenings due to high costs, family obligations, or disability [7,30,31,50]. Virtual convenings lower barriers to participation by eliminating travel and lodging costs and make events more convenient for individuals balancing other commitments.

Our results echoed prior studies about the benefits of online convenings, including increased accessibility leading to more diverse participation, and a lower carbon footprint [6,7,22–29,31,50]. All outcomes, which included enjoyment and satisfaction, knowledge acquisition, action orientation, and expanded social networks, produced an average

response above the midpoint on five-point scales. Making new connections with others and engaging in meaningful interactions scored the lowest, echoing the findings of respondents' assessments of the shortcomings in networking opportunities in virtual convenings noted above.

4.2. Implications for Social Learning in Virtual Contexts

Social learning relies on "bringing together people of various backgrounds and with different values, perspectives, knowledge and experiences, both from inside and outside the group or organization, to engage in a creative quest for answers to questions for which no ready-made solutions are available . . . Social learning is a process in which people are stimulated to reflect upon implicit assumptions and frames of reference, in order to create room for new perspectives and actions" [18] (p. 11). Our results aligned with many elements of social learning. Respondents valued hearing from diverse perspectives and from people with different types of knowledge and expertise [14,17–19,51,52]. In particular, attendees appreciated hearing Indigenous and youth perspectives. Youth have been shown to benefit from and contribute to adaptation convenings. MacKay et al. found that Indigenous youth gained confidence, inspiration from each other, and interest in engaging in governance after attending COP24 virtually [53]. The fact that the small group of survey respondents who were Indigenous stated a strong preference for virtual convenings is important to consider if conference planners aim to include more Indigenous participation and perspectives in convenings. However, more data should be collected to ascertain the generalizability of this preference.

Attendees expressed desires to interact more with colleagues, and discuss ideas rather than just listen to presentations [18,31,51,52]. While question-and-answer sessions were appreciated, some felt that the need to communicate through a moderator limited meaningful interaction. Many also expressed desires to communicate with other attendees, not only the speakers. Study participants suggested enabling more forms of open discussion immediately following presentations. These opportunities would allow for a more multi-directional interchange of ideas and knowledge, as promoted in prior research [19] rather than a more traditional presentation focused on one-directional knowledge dissemination.

Respondents also noted challenges with staying engaged on-screen for long periods of time. Regularly scheduled breaks may allow people to avoid screen fatigue, and be more likely to participate in networking sessions, which were under-attended despite a general recognition of their importance. Attention theories support the notion of balancing on-screen time with breaks [54]. Moreover, conveners might brainstorm re-balancing the traditional agendas of in-person formats, which tend to focus on presentations and rely on attendees to network in common spaces outside of scheduled content delivery, to purposefully include more opportunities for spontaneous discussions and networking. This might include both facilitated or informal discussion groups centered around specific topics or questions, extended discussion spaces after presentations, or other creative ways engage outside of formal presentations. Many of these findings related to scheduling and social learning in CoPs may apply to in-person events as well. Study participants noted the particular value of mentoring sessions, small breakout rooms with guiding questions, and one-on-one meetings via video chat. Creating and emphasizing these opportunities may help attendees plan ahead to better engage in them, as they likely already plan for which presentations to attend. Similarly, facilitators might encourage participants to limit the number of sessions they view online in a given time period. Recording sessions for later viewing could help to support this effort and was mentioned by several respondents. As is the case with in-person events, one can never attend all of the sessions that might seem of interest, requiring participants to make sometimes challenging decisions.

Hybrid opportunities also show promise to enhance social learning through more varied and deeper interpersonal engagement. Hybrid convenings provide the option for people to attend in-person and were appreciated by attendees, but there was a disconnect between attendees who are there in-person and online attendees. Additionally, the costs

of providing both may be prohibitive for meeting organizers and participants who would like to attend online. Smaller localized gatherings of virtual attendees for watch parties, discussion groups, or other conference-related events could improve the typical experience for virtual attendees of sitting alone in front of a screen, disconnected from the interpersonal interactions which they value at an in-person event, while keeping travel fees low and avoiding some of the disconnects between attendees who select different formats.

5. Limitations

Surveys were designed in collaboration with each conference's conveners. As a result, each convening group modified some of our original survey question language to obtain relevant data for their purposes. We were, however, able to employ a consistent set of Likert-type items measuring key outcomes across all convenings. We did not ask for the age of participants or whether participants had attended more than one past convening of a particular conference. Thus, we cannot draw conclusions regarding age differences or differences between long-term repeat attendees and newer participants. The sample size of only four convenings may also limit the broader generalizability of the findings.

6. Conclusions

Climate adaptation is a transdisciplinary challenge that requires diverse stakeholders to come together to develop and implement solutions. This work relies heavily on social learning of diverse actors. Our findings extend prior research by comparing knowledge gain in virtual events and in-person convenings—finding it to be similar for most attendees. Additionally, we found that the majority of participants reported being more likely to attend online formats in the future. Similar to other studies, we found online convenings to be easier for a wider array of people to attend, cost less, and have auxiliary environmental benefits. Attendees of these four convenings appreciated that virtual convenings were more accessible than in-person convenings and included a variety of diverse perspectives, (e.g., youth and Indigenous perspectives), which were valued. Environmental benefits were mentioned most often by participants at a conference that reported greenhouse gas emission savings attributed to the virtual format. That conference used an "Uncarbon Calculator" to remind attendees about the environmental impacts of in-person convenings, and could be a model for others (see Figure 3).

Based on our participant responses, we suggest that conference planners include more opportunities for discussions and multidirectional idea exchange, rather than traditional formats where participants simply listen to presentations or panels. In some cases, discussions were constrained by limitations of online platforms. In other cases, compressed schedules did not provide time for discussions at the end of each session.

The quality of social networking elements, which are crucial to social learning, was rated as suboptimal by participants. Social networking opportunities, such as small group video discussions with icebreaker questions and mentoring sessions, were appreciated. However, in many cases, online social networking events were sparsely attended, indicating either a need for better marketing of these events or for better design to meet the desires of participants. Some attendees suggested virtual convenings with small regional gatherings to enhance networking.

Virtual convenings have the potential to enable climate adaptation communities to "walk the walk" toward more diverse and accessible convenings with lower carbon emissions. However, our study of these four convenings suggest some shortcomings in social learning and relationship-building in these events. We thus urge future research and practical experimentation focusing on enhancing these social components and evaluating a broad set of outcomes their manipulation might be able to achieve. Research that includes information about the differences in experiences and outcomes for attendees of different sociodemographic backgrounds could also provide valuable insights.

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Appendix A

Open-ended Questions about Attendee Experiences (listed by convening)

At What Point Managed Retreat? Resilience, Relocation and Climate Justice 22–25 June 2021

1. As you return home, what are the next steps for you in terms of actions (if you are involved in local responses) or collaborations (research or policy oriented) that are informed by this conference?
2. Looking back, what would have back the conference better? What changes, if any, would you make?
3. What did you like most about this year's online conference?
4. What would you have liked to hear more about at this conference? Was a perspective or voice missing or underrepresented?
5. Please use the space below to share any additional feedback about this conference.

11th Northwest Climate Conference

1. What did you find most useful about the online platform?
2. What did you like most about this year's online conference?
3. Which conference session(s) did you find most interesting (if any) and why?
4. Looking back, what would have made the conference better? What changes, if any, would you make?
5. Please explain your (format) preference below (virtual vs. in-person). What do you feel are the primary advantages and disadvantages of each format?
6. Please use the space below to share any additional feedback about this conference, including ideas for future topics to be addressed at the next conference and other organizations/listservs where the conference should be promoted.

2021 Carolinas Climate Resilience Conference

1. Do you have suggestions to improve any aspects of the conference?
2. What is the most valuable thing you learned during the conference (optional)?
3. Please comment on your experience participating in the Carolinas Climate Resilience Conference as a hybrid event. What worked well? What did not work as well? (optional)

13th Annual Climate Leadership Summit

1. Following this event, what are the next steps for you in terms of actions (if you are involved in local responses) or collaborations (research or policy oriented) that are informed by this summit?
2. What did you like most about this year's online summit?

3. Looking back, what would have made the summit better? What changes, if any, would you make?
4. Please use the space below to share any additional feedback about this summit.

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