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RESEARCH ARTICLE

Supporting Indigenous adaptation in a changing climate: Insights from the Stó:lō Research and Resource Management Centre (British Columbia) and the Fort Apache Heritage Foundation (Arizona)

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Indigenous peoples are both disproportionately threatened by global climate change and uniquely positioned to enhance local adaptive capacities. We identify actions that support Indigenous adaptation based on organizational and community perspectives. Our data come from two Indigenous organizations that share cultural heritage stewardship missions—the Stó:lō Research and Resource Management Centre (Stó:lō Nation, British Columbia) and the Fort Apache Heritage Foundation (White Mountain Apache Tribe, Arizona). These organizations collaborated with us in exploring community perceptions of climate effects, investigating community adaptation opportunities and constraints, and identifying actions that support Indigenous adaptation. Research methods included engagement with organizational collaborators and semi-structured interviews with organizational representatives and community members and staff. Results confirm that Stó:lō and Apache territories and communities have experienced climate change impacts, such as changes in temperature, hydrology, and increase in extreme weather events. Climate effects are cumulative to colonial depletion of traditional environments and further reduce access to traditional resources, practices, and food security. Results indicated that certain actions are identified by community members as adaptation enablers across case studies—most prominently, perpetuation of Indigenous culture and knowledge, climate education that is tailored to local contexts, collaborative decision-making among community institutions, and integration of climate adaptation into ongoing organizational programs. We conclude that Indigenous-owned organizations are engaged in the expansion of adaptive capacity and hold potential to further support their communities.

Keywords: Indigenous adaptation, Indigenous organization, Indigenous perspectives of climate change, Traditional knowledge, Climate adaptation, Adaptive capacity

1. Introduction

Indigenous peoples have unique, ancestral relationships to their traditional lands and environments. Despite colonial and ongoing efforts to commodify Indigenous territories and assimilate Indigenous cultures, these peoples continue to exercise inherent rights to self-determine their beliefs, traditions, and stewardship duties (UN General Assembly, 2007). Long-standing and reciprocal relationships among Indigenous peoples and territories are grounded in traditional knowledge systems and holistic understandings of the interrelatedness of all entities and elements (Turner et al., 2000; Watson et al., 2003; Whyte, 2017). Traditional knowledge often encompasses both general ways of learning, knowing, and acting and specific strategies for sustainable resource harvesting, monitoring, and relationship adjusting (Turner et al., 2000; Whyte, 2017). Through commitments to the wellness of other-than-human beings and the stewardship of ancestral connections, lands, communities, and relationships are maintained (McHalsie, 2007; Atleo, 2014).

Indigenous peoples are disproportionately threatened by a changing climate relative to non-Indigenous groups (Maldonado et al., 2013; Bennett et al., 2014). Detrimental impacts to traditional environments constitute threats to Indigenous cultures, languages, lifeways, knowledge systems, and peoples (Turner and Clifton, 2009; Turner and Spalding, 2013; Jantarasami et al., 2018). Further, the climate vulnerability of Indigenous communities cannot be separated from the history of Western colonization (Maldonado et al., 2013; Redsteer et al., 2013). Colonial policies have led to socioeconomic vulnerabilities in Indigenous communities, restricted community access to financial and technological resources, and pushed

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Indigenous settlements to remote and often environmentally compromised margins. These heightened natural and socioeconomic vulnerabilities mean that Indigenous peoples are both disproportionately exposed and often less equipped to respond to climate change relative to non-Indigenous communities (Bennett et al., 2014). The almost complete lack of relocation options is especially daunting (Maldonado et al., 2013; Romero Manrique et al., 2018).

To comprehend and empower Indigenous responses to climate change, it is essential to differentiate between increased climate vulnerability and insufficient adaptive capacity. Adaptive capacity is defined here as the ability to adjust to climate change, meaning that adaptation is a manifestation of adaptive capacity (Smit and Wandel, 2006, p. 286). Adaptation seeks to moderate climate change effects, avoid harmful effects, or enable benefits deriving from climatic change (IPCC, 2014). Despite vulnerabilities stemming from colonial impositions, Indigenous peoples are exerting adaptive capacity and finding solutions to adapt to climate impacts (see Nania et al., 2014; Schlingmann et al., 2021). For example, there is growing evidence that Indigenous ways of seeing, knowing, and relating to the environment can enhance capacity to adapt to climate change within and beyond Indigenous contexts (Green et al., 2010; Berkes, 2012; Turner and Spalding, 2013; Williams and Hardison, 2014; Sanderson et al., 2015; Makondo and Thomas, 2018; Romero Manrique et al., 2018).

Because each Indigenous community in North America has unique relationships with territory and colonial experiences, generalizations are hazardous. That said, U.S. Tribes and Canadian First Nations are experiencing some common climate impacts, including decreases in water availability, increases in frequency and severity of extreme weather events and wildfires, traditional food shortages, and reduced snowpacks (Centre for Indigenous Environmental Resources, 2008; Lynn et al., 2013; Bennett et al., 2014). Such impacts constitute risks to resource-dependent and subsistence economies and cultures (Huntington et al., 2017; Jantarasami et al., 2018). Climate impacts to tribal lands, water, and traditional foods and resources are threatening Indigenous health, including physical and spiritual impacts linked to historical, cultural, and emotional connections to territory (Jantarasami et al., 2018).

For Indigenous groups to mitigate vulnerabilities to climate change and harness advantages from local knowledge and from social, political, and organizational assets, insight is needed into factors that support climate adaptation of Indigenous communities in specific circumstances and more generally. Existing literature emphasizes the relevance of traditional knowledge in adapting to climate change (Green et al., 2010; Berkes, 2012; Turner and Spalding, 2013; Williams and Hardison, 2014; Sanderson et al., 2015; Makondo and Thomas, 2018; Romero Manrique et al., 2018). However, more information is needed regarding other factors specifically relevant to Indigenous community adaptation. In this article, we identify actions that support adaptation to climate change in Indigenous community contexts. Our results come from a qualitative comparison of two case studies conducted with Indigenous organizations and associated community members. Our aim is to increase knowledge regarding Indigenous community adaptation and to make recommendations to enable climate adaptation in Indigenous community contexts. Our conclusions and recommendations primarily target Indigenous organizations and their collaborators but also apply to non-Indigenous actors involved in climate adaptation in Indigenous and place-based community contexts.

We conducted case studies in collaboration with two Indigenous-owned organizations, the Stó:lō Research and Resource Management Centre (SRRMC; Stó:lō Nation, British Columbia) and the Fort Apache Heritage Foundation (White Mountain Apache Tribe, Arizona). The two organizations serve their respective communities through similar missions focused on cultural heritage stewardship and commitments to Indigenous self-determination. The participant organizations welcomed our research as important steps toward integrating biophysical issues into cultural heritage stewardship and building organizational capacities to support communities in adapting to climate change. Our qualitative comparisons took shape and direction based on communities' interests in climate change adaptation, the participant organizations' parallel missions, and both similarities and differences in regional biophysical profiles and experiences of climate change. The case studies evolved to embrace recommendations for deploying Indigenous organizational assets for climate adaptation regardless of local climate effects.

Concepts of adaptation constraints and opportunities proved centrally important in our collaborations. Klein et al. (2014) define adaptation constraints as factors that hinder adaptation; opportunities, in contrast, enable or increase the likelihood of adaptation (Klein et al., 2014). Adaptation actions are more successfully implemented in contexts where community members are included in the adaptation process, are aware of the need to adapt, and are willing to do so (Biagini et al., 2014). Hence, we developed this study based on a premise that community-based Indigenous organizations constitute opportunities to support bottom-up community adaptation processes.

The next section of the article describes the participant Indigenous organizations—the SRRMC and the Fort Apache Heritage Foundation—and associated case studies. We reference the case studies and research participants simply as "Stó:lō" and "Apache". Section 3 describes data collection and analysis processes. Sections 4 and 5 report our findings regarding cumulative effects of perceived climatic and environmental changes to communities, community adaptation to effects, adaptation opportunities and constraints, and organizational services supporting community adaptation. Section 6 addresses actions that support climate adaptation in Indigenous communities based on case study results. We conclude with considerations for future research and implications for Indigenous communities.

2. Case studies

2.1. SRRMC

The Stó:lō are a supra-tribal collective of Halq'eméylem-speaking peoples whose traditional territory is centered

on the Lower Fraser River in British Columbia (BC), Canada. For the Stó:lō, this is S'ólh Téméxw ("Our World" or "Our Land"; Schaepe, 2007, p. 246). The Stó:lō have inhabited the Lower Fraser River watershed since time immemorial and self-identify as people of the "river of rivers" (Carlson, 2001a, p. 24). The Stó:lō were precolonially organized into tribes inhabiting the Lower Fraser River and are associated with a broader cultural group that is referred to as the Coast Salish (Schaepe, 2009). Stó:lō tribes and land have been divided as a result of assimilation practices since the Fraser River Gold Rush of 1858 (Carlson, 2001b). The Indian reserves established by the Canadian government represent less than 1% of S'ólh Téméxw. **Figure 1** depicts S'ólh Téméxw.

The SRRMC is based in Chilliwack and is a branch of Stó:lō Nation—the political amalgamation of eleven Stó:lō First Nations. SRRMC's mandate is to enable Stó:lō communities to protect, preserve, and manage Stó:lō heritage according to the principle of Stó:lō stewardship "*S'ólh Téméxw te íkw'élò. Xólhmet te mekw' stám ít kwelát*" ("This is our land. We have to look after everything that belongs to us"). The SRRMC provides professional and technical services to all Stó:lō First Nations, specializing in areas such as support of Stó:lō self-governance, heritage and environmental research and resource management, collaborative stewardship, geographic information systems, cultural education, among others (SRRMC, n.d.). The organization also functions as a center for the creation, curation, and mobilization of knowledge and materials of value to the Stó:lō.

The Stó:lō have witnessed significant changes to their traditional lands and environments. S'ólh Téméxw is a territory that has suffered from intense urbanization, resource development, and environmental change (Thom and Cameron, 1997; Duffield, 2001; Woods, 2001). Road and freeway building, diking for flood prevention, lake draining, forestry and agricultural development, and encroachment comprise some of the most significant impacts that have historically altered the region (Thom and Cameron, 1997). The result has been considerable losses in traditional resources and use areas for Stó:lō communities (Thom and Cameron, 1997). Some of these development processes, such as diking, have also affected Fraser River salmonids (Harper, 1997). The Stó:lō have been fishers since time beyond memory and have a close relationship with salmon as an ancestor and as the primary staple in their traditional diet (Cameron, 1997; Deur, 1999; Smith, 2001; McHalsie, 2007). Resource pressure to the territory subsists, stemming from public, industrial, and residential development proposals (Brady, 2013).

Climate change is causing impacts to S'ólh Téméxw that are cumulative to historical and ongoing development pressures. Climate impacts to the Fraser River and its salmonid populations are evident. Ongoing impacts include increase in Fraser River temperatures, reduction in snow water contents, and earlier snowmelt and discharge (Shrestha et al., 2012). Morrison et al. (2002) estimate that mean summer river temperatures increased at a rate of 0.22 °C per decade for the 1953–1998 period. Pacific salmon (*Oncorhynchus spp.*) are sensitive to

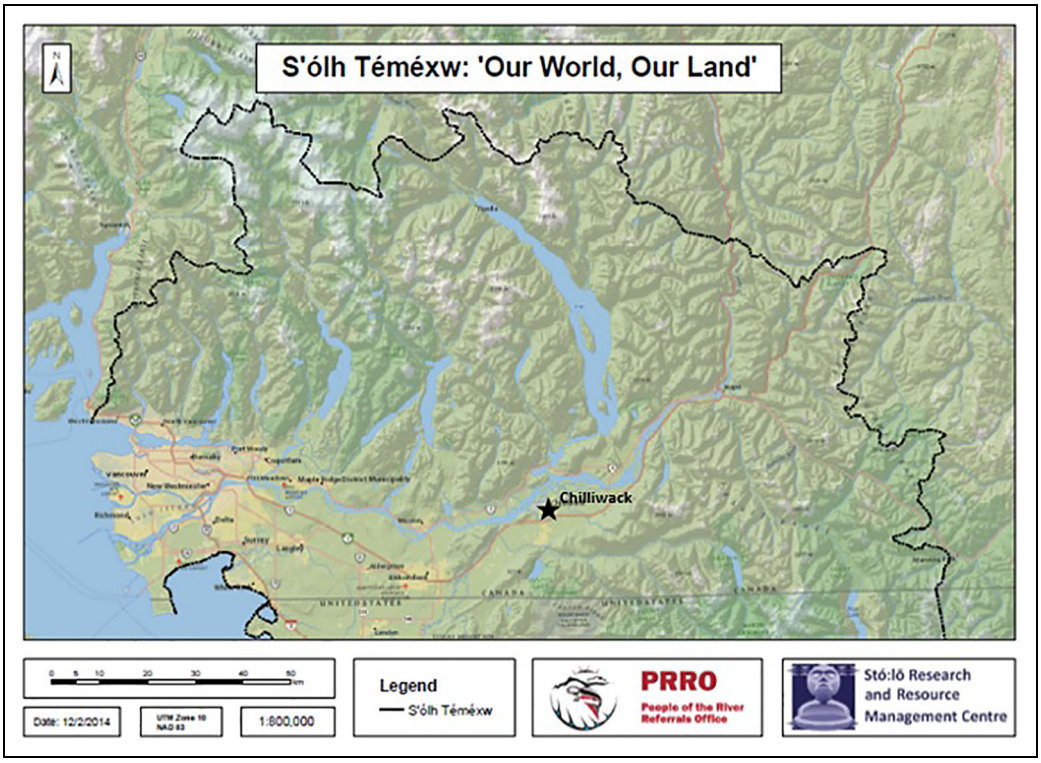

Figure 1. S'ólh Téméxw. The city of Chilliwack, BC, designated with a black star, is home to the Stó:lō Research and Resource Management Centre. Stó:lō Connect. Used with permission. DOI: https://doi.org/10.1525/elementa.2020.00164.f1

changes in water temperature, where species and populations differ in their thermal windows (Pörtner and Farrell, 2008). Morrison et al. (2002) project that river temperature threat to Fraser River salmon will experience a 10-fold increase for the 2070–2099 period, compared to the baseline period of 1961–1990. The year 2020 brought the lowest sockeye salmon (*Oncorhynchus nerka*) run in the Fraser River since tracking started over a century ago (Pacific Salmon Commission, 2020). Although climate impacts may increase salmon productivity in the northern range of Pacific salmon, studies estimate greater risk of future losses for sockeye salmon and other fisheries in the southern range, where Stó:lō territory lies (Healey, 2011; Campbell et al., 2014).

2.2. Fort Apache Heritage Foundation

The Fort Apache Indian Reservation covers about 1.6 million acres in the eastern Arizona uplands and is home to the White Mountain Apache Tribe. The reservation comprises the portion of Western Apache Indigenous Territory set aside by the United States for the exclusive benefit of White Mountain and Cibecue Apaches. Ongoing Western Apache identification with their homeland is reflected in the Apache word *ni'*, meaning land, mind, country, and way of thinking (Welch, 2009, p. 151).

Fort Apache was originally established in 1870 as a U.S. military facility with the consent of local Apache leaders but soon emerged as a tool for colonial disenfranchisement (Welch, 2019). In 1922, the Army abandoned the post, and the Fort Apache property was transferred to the Department of Interior and employed as an Indian residential and day school, the Theodore Roosevelt School (TRS). For nearly a century, TRS has enrolled children with varied Native American backgrounds to advance shifting Federal Government educational policies. The 26 historic buildings and about 300 acres of land comprising the Fort Apache property were placed in perpetual trust for the Tribe in 1960 (Welch, 2019, p. 77). In 2012, the Federal Government recognized the property's significance via designation as the Fort Apache and TRS National Historic Landmark (Welch, 2019, p. 80; **Figure 2**).

The White Mountain Apache Tribe (Tribe) chartered the Fort Apache Heritage Foundation (Foundation) as a nonprofit with the Internal Revenue Service in 1997 to advance Apache interests in the Fort Apache and TRS National Historic Landmark. The Foundation is committed to repurposing this site of colonial subjugation and residential school oppression to a place that advances Apache pride, sovereignty, and capacity building. The Foundation advances the Tribe's self-determination through stewardship of Fort Apache in pursuit of education, cultural perpetuation, community health, and economic development. The Foundation has stabilized and rehabilitated the 23 historic buildings under its management at Fort Apache and continues to create opportunities and benefits for the Tribe and its members (Welch, 2019).

Climate change effects are emerging as major risks to the Tribe. Climate change is leading to lower spring snowpack, increases in the proportion of rain to snow, lower spring and summer runoff, drier summer conditions,

Figure 2. White Mountain Apache Reservation. Fort Apache is located within the White Mountain Apache Reservation in eastern Arizona. Source: Adapted from Welch et al., 2009. Used with permission. DOI: https://doi.org/10.1525/elementa.2020.00164.f2

reduced soil moisture, and intensified droughts across the Southwest United States (Cayan et al., 2013; Garfin et al., 2018). Arizona has seen progressively diminishing snowpacks since the 1950s and decreased annual precipitation (U.S. Environmental Protection Agency, 2016). Increased drought and lower soil moisture during fire season, in conjunction with earlier spring seasons and higher temperatures, boost wildfire risk (Fleishman et al., 2013). The frequency and severity of wildfires have increased throughout the western United States since the 1970s, and this trend is expected to continue (Fleishman et al., 2013; Garfin et al., 2018). Arizona experienced an average of 11 more large wildfires (larger than 1,000 acres) per year during the period 2010–2015 compared to the 1970s (Kenward et al., 2016). Warmer temperatures, increased drought, and wildfires can further affect agriculture, livestock production, and public health throughout Arizona (U.S. Environmental Protection Agency, 2016). The Tribe was especially affected by the Rodeo-Chediski fire in 2002. The fire burned more than 200,000 acres of the reservation and led to sawmill closures, decimating the Tribe's revenues and jobs base (Keller, 2005).

3. Methods

Western scientific research has too often represented "an extension of the Indigenous-settler colonial project" (Kovach, 2009, p. 142). Tuhiwai Smith (2012, p. 31) depicts Western research as a "site of struggle" between Western and non-Western interests, where research systematically catered to researchers' interests while being detrimental or plainly useless to Indigenous communities. Today, protocols for research with Indigenous communities often

mandate community participation, participant consent, and research goals and processes optimized to accrue local benefits (Kovach, 2009). We embraced considerations for ethical and reciprocal research in Indigenous contexts and tailored our work to advance the interests of the participant organizations and communities. As non-Indigenous researchers, we do not presume to have followed Indigenous methodology, which is distinct from qualitative methods and rooted in Indigenous language and tribal epistemologies (Kovach, 2009).

Research methods involved engagement with research collaborators from the participant organizations, semi-structured interviews, organizational document reviews, and qualitative content analyses using QSR International's NVivo 12 software. Long-standing community engagements on the part of Schaepe (Stó:lō) and Welch (Apache) facilitated project approvals and participant recruitment. We developed the research design, primary objectives, and interviewee recruitment in collaboration with participant organization representatives and community leaders. Research collaborators assisted in the identification of potential interviewees, who were invited to participate by email or telephone. Potential interviewees were contacted based on their knowledge and ability to provide input to research objectives—for example, knowledge of traditional territories and practices, environmental expertise, leadership in communities, and knowledge of participant organizations' activities were considered. Interviewees included participant organization board members and staff, community members, and community staff. We also asked research participants to suggest community members possessing knowledge relevant to research objectives, a "snowball" recruitment strategy. Given the organizational focus, the research made no attempt to specify or mobilize the perspectives of individual Stó:lō First Nations or of the Tribe, per se.

The participant organizations, the Tribe's Tribal Plan and Project Review Panel, and Simon Fraser University's Office of Research Ethics reviewed and approved the research proposal, the semi-structured interview guide (Text S1), and the participant consent form. The participant consent form confirmed that participation was voluntary, explained research objectives, and affirmed participant discretion over the disclosure of their names in research outcomes. Participants who elected to remain anonymous were assigned pseudonyms. Participants also had the opportunity to orally consent to being recorded or not. We did not offer financial incentives to participate in the project.

Data collection involved on-site information compilation and 27 semi-structured interviews—14 interviews at and around Fort Apache (Arizona) during May and June 2017 and 13 interviews at and around the SRRMC (Chilliwack, BC) between July and November 2017. Semi-structured interviews explored perceived climatic and environmental changes to territories and their effects on communities, community adaptation actions, perceived adaptation opportunities and constraints, and organizational support for community adaptation. Interviews were, on average, between 1 and 1.5 h in length. Audio recordings captured all but one of the interviews. **Table 1** lists case study research participants and provides additional details, including participants' relationships to Indigenous organizations and communities.

We performed systematic qualitative and inductive content analyses of the text data. NVivo 12 was used to code all substantive text elements and identify patterns in co-occurrence (Hsieh and Shannon, 2005). Organizational documents provided contextual and complementary information to develop organizational recommendations and were not included in the content analysis. Content analysis began with a reading of interview transcriptions, followed by the identification and coding of text according to meaning units, the smallest units of text that relate to research objectives (Bengtsson, 2016). All coded material was then imported to NVivo and categorized into domains based on the different themes that guided interview questions, or "broad groups based on different attentions of the study" (Bengtsson, 2016, p. 12). **Table 2** describes data analysis domains. Domains were further developed into categories for content analysis. This process was completed separately for each case study. Hippmann Gauer (2019) provides conclusions and recommendations specific to each participant organization.

4. Stó:lō case study results

4.1. Cumulative effects

Stó:lō participants consistently reported observing a decline in Fraser River salmonid populations and reduced availability and health of traditional plants and medicines in the territory, such as western-red cedar (*Thuja plicata*) and wild berries. It is unclear whether impacts to traditional plants are attributable to global climate change. Changes to the Fraser River, such as warmer river temperatures, lower water levels, more variable water levels, and lower water quality, were also consistently reported. Warmer river temperatures are among the drivers of Fraser River salmon decline, as discussed in Section 2.1. Other observations included warmer and drier summers, reduced snowfall, and perceptions of increased risk of floods and wildfires.

The importance of Fraser River salmon cannot be overstated. The Stó:lō self-identify as "salmon people"; they are "fish in essence" (M Ned, personal communication, 2017). The possibility of salmon disappearing from the Fraser River is described as "disastrous" (E Gardner, personal communication, 2017). The decline in Fraser River salmon is detrimental to Stó:lō fisheries and community food security. Salmon catches comprise an important food source for Stó:lō members and are shared in ceremonies and winter gatherings (J Dandurand, personal communication, 2017). Substituting store-bought foods for wild salmon constitutes an added expense that can be financially challenging for households. Salmon scarcity also leads to store-bought substitutions in traditional ceremonies, which is perceived as "sad" and as "part of the tradition that is being lost" (M Ned, personal communication, 2017). Sharing traditional foods in ceremonies has a spiritual significance as it comprises a means to connect with

Table 1. Research participants. DOI: https://doi.org/10.1525/elementa.2020.00164.t1

Participant Name	Interview Date	Relation to Organization	Affiliation	Case Study
Naxaxalhts'i, Albert "Sonny" McHalsie	July 24, 2017	Staff	Shxw'owhamel First Nation	Stó:lō
Alexis[a]	May 30, 2017	Confidential	Tribal member	Apache
Ali[a]	May 30, 2017	Confidential	Tribal member	Apache
Angel[a]	June 1, 2017	Confidential	Tribal member	Apache
Avery[a]	June 1, 2017	Confidential	Tribal member	Apache
Brenda Pusher-Begay	May 31, 2017	External	Tribal member	Apache
Carrielynn Victor	November 23, 2017	External	Cheam First Nation	Stó:lō
Cheryl Pailzote	May 24, 2017	External	Tribal member	Apache
Clarence "Kat" Pennier	September 21, 2017	External	Sq'éwlets First Nation	Stó:lō
Cline Griggs	May 24, 2017	External	Tribal member	Apache
David Schaepe	July 24, 2017	Staff	Unaffiliated	Stó:lō
Eddie Gardner	July 28, 2017	External	Skwah First Nation	Stó:lō
Ernie Victor	July 26, 2017	Staff	Cheam First Nation	Stó:lō
Gwendena Lee-Gatewood	May 24, 2017	External	Tribal member (now Chairwoman)	Apache
Karl Hoerig	May 24, 2017	Staff	Tribal staff	Apache
Krista Beazley	July 2, 2017	Staff/CEO	Tribal member	Apache
Joseph Anthony "Tony" Dandurand	September 22, 2017	External	Qw'ó:ntl'an First Nation	Stó:lō
Leeann Lacapa	May 31, 2017	Board of Directors	Tribal member	Apache
Maretta Beger	July 18, 2017	Staff	Skwah First Nation	Stó:lō
Murray Ned	September 21, 2017	External	Sema:th First Nation	Stó:lō
Patricia "Tia" Halstad	July 26, 2017	Staff	Unaffiliated	Stó:lō
Rochelle Lacapa	May 26, 2017	Board of Directors	Tribal member	Apache
Rowena Cooya	May 31, 2017	Board of Directors	Tribal member	Apache
Shana Roberts	July 25, 2017	Staff	Unaffiliated	Stó:lō
Shannon Tsosie	May 24, 2017	Board of Directors	Tribal member	Apache
Stephen McGlenn	September 14, 2017	External	Sema:th First Nation staff	Stó:lō
Taylor[a]	July 24, 2017	Confidential	Unaffiliated	Stó:lō

[a]Pseudonym.

Table 2. Data analysis domains. DOI: https://doi.org/10.1525/elementa.2020.00164.t2

Domain	Description
Cumulative effects	Observations of climatic and environmental changes to traditional territories and associated effects on communities
Adaptation actions	Reported adaptations being undertaken at the community or individual level
Adaptation constraints	Factors perceived as constraining community adaptation
Adaptation opportunities	Factors perceived as enabling or promoting community adaptation
Organizational roles	Perceptions of current and potential organizational efforts to support community adaptation

ancestor spirits (S McHalsie, personal communication, 2017). Further, Stó:lō lifeway traditionally centers on fishing (Cameron, 1997; Macdonald, 2018). J Dandurand (personal communication, 2017) commented on the impact of lack of fish as an impact to a way of life:

> *It is incredible to see that [lack of fish] happen. I don't know what we do because we are river Indians, you know, we are all fishermen and we all live on the river and the river has always been our food source for thousands of years now.*

4.2. Adaptation actions

Stó:lō community members are constantly identifying environmental changes to S'ólh Téméxw and adapting accordingly. As resources become less available or geographical distributions shift, community members are using more remote parts of their territory to maintain traditional plant gathering and hunting practices (C Victor, personal communication, 2017). Changes in the timing of salmon returns similarly lead community members to adjust the timing of associated ceremonies (M Ned, personal communication, 2017). Despite efforts toward adaptation of traditional practices to changing climatic and environmental conditions, store-bought foods are increasingly displacing traditional foods and reducing food security (S McHalsie, personal communication, 2017).

Stó:lō participants conveyed that stewardship of traditional use areas and resources is a significant adaptation effort, as it can assert Indigenous rights and mitigate harm to stressed populations—some of which are estimated to be further affected by climate change effects, such as Fraser River salmonids (e.g., E Gardner, personal communication, 2017). Stó:lō communities and organizations exert stewardship by engaging in wild salmon conservation advocacy and in integrated fisheries management (M Ned, personal communication, 2017). E Gardner (personal communication, 2017) explained how traditional use of the territory asserts Indigenous rights and proactively protects resources:

> *There is a lot of people in the communities who . . . are making their own decisions about what needs to be done to prepare for climate change. So, they are going out . . . to live off the land, to know where the berries are, to know where the animals are so they can hunt, and fish, and exercise their rights to harvesting. . . . And if there is an industrial activity that is threatening our fish, or our hunting grounds, or our medicines and food, then . . . they are saying, "Hey, they shouldn't be able to do this because this is what is at stake. We know because we are out there, this is where we are actually using our land."*

4.3. Adaptation constraints and opportunities

The major adaptation constraint for the Stó:lō lies in their (in)ability to meaningfully engage in decision-making regarding the current and future management of their traditional territories (C Pennier, personal communication, 2017). Treaties were never completed in Stó:lō territory; consequently, the Stó:lō never surrendered rights to their traditional territory (Carlson, 1997a). Indigenous rights need to be fully recognized and respected for the Stó:lō to effectively exercise their rights to use, manage, and protect their traditional territories beyond Indian reserves. Whenever governmental decisions or legislation infringe on Indigenous rights, the Crown has a duty to consult with the affected people (Isaac and Knox, 2003). Requests for consultation processes that are not perceived as meaningful and that burden First Nations' technical and administrative capacities are significant challenges in BC and elsewhere (Baker and McLelland, 2003; Marsden, 2006; Booth and Skelton, 2011). Insufficient financial and technical capacity were also mentioned as adaptation constraints.

Stó:lō participants emphasized that Stó:lō culture and knowledge perpetuation, collaboration among Stó:lō First Nations, and Indigenous rights recognition would enable climate adaptation. These elements comprise a reaction to decreased adaptive capacity inflicted by colonial policies, such as Stó:lō fragmentation into Indian bands and reserves (Carlson, 2001b) and historical lack of treaty-making (Carlson, 1997a). J Dandurand (personal communication, 2017) mentioned that Stó:lō elders are "very young in the sense that they didn't really grow up with the old ways," meaning that a portion of Stó:lō traditional knowledge has been eroded by colonial processes. Indigenous cultural perpetuation initiatives seek to curb such losses and promote transfers of traditional knowledge and practices across communities and generations.

Stó:lō participants emphasized that cultural practices enhance adaptive capacity by supporting community members' connections to one another in a shared territory, tradition, and culture. E Gardner (personal communication, 2017) explained that the Stó:lō are stronger as a collective that shares a culture:

> *We belong together. We belong to a territory. . . . We share the songs, we share the ceremonies that we have. That is the way that we connect to one another through our ceremonies and our way of living. . . . It is something that other cultures cannot take away from us.*

Traditional knowledge and practice are also perceived as important means for individual and community adaptation and survival. Some participants expressed that their traditional practices may be an advantage during challenging times, as they possess the necessary skills to survive off their lands and environments, instead of being dependent on coordinated societal functioning to meet their basic needs (e.g., C Victor, personal communication, 2017). Dependence on store-bought foods over traditional foods is seen as exacerbating vulnerability to market fluctuations, to climate change effects on global food production, and to potential societal disruptions (C Pennier, personal

communication, 2017; C Victor, personal communication, 2017).

Enhanced collaboration among Stó:lō Nations is mentioned as another adaptation opportunity. Relationships among First Nations and territories have been interrupted by colonial policies and practices. Canadian federal legislation, particularly the Indian Act, established repressive policies and altered Stó:lō society for assimilation purposes (Carlson, 1997b; Tennant, 2011). The division of Stó:lō tribes into Indian reserves restricted communities to tracts of land that are minute compared to traditional territories (Carlson, 1997a). Band designation has affected how Coast Salish people self-identify and fostered competition among bands (C Pennier, personal communication, 2017). S McGlenn (personal communication, 2017) described how this has affected the Sema:th First Nation:

> *Before the Indian Act, Leq'á:mel and Sema:th were one and the same tribe. . . . When the reserves were created, they decided to split them into two different Chief and Councils, because of the geographic separation from the river. So, all the historic, thousands of years of family connections were suddenly severed between the two communities. And we are trying to rebuild those relations.*

As a result of such colonial policies, traditional mechanisms for intercommunity communication among Stó:lō Nations and Stó:lō neighbors require redress: "In regards to climate change, I don't see anything. . . . How other Nations farther north to us are being affected by water levels, I don't know, I have no idea. Because there is no communication between us, or a group studying it" (J Dandurand, personal communication, 2017). Enhanced collaboration and solidarity among Stó:lō First Nations are identified as essential to efficiently employ scarce assets for common adaptation objectives (M Ned, personal communication, 2017), to assert Indigenous rights, and to guide governmental adaptation funding according to common interests and needs. M Ned (personal communication, 2017) stated that if the Stó:lō "could speak as one . . . they would carry more strength when trying to deal with government."

4.4. Organizational roles

Participants indicated that the SRRMC supports community adaptation mainly through its technical and research capacity, thereby filling community capacity gaps, as well as through cultural perpetuation and information housing services. The SRRMC assists in the perpetuation of Stó:lō culture and knowledge through cultural tours, traditional use research, material culture curation, cultural information compilation and housing, and cultural education activities and publications. The SRRMC has also started engaging in collaborative stewardship planning and adaptation planning with Stó:lō communities since data collection was completed (D Schaepe, personal communication, 2019).

SRRMC can further mainstream climate adaptation into its ongoing programs. This potential lies in SRRMC's capacity to identify drivers of cumulative effects to S'ólh Téméxw through the accumulation of information on Stó:lō Connect, an online portal linking Stó:lō communities to one another and to government and industry proponents of land alterations throughout S'ólh Téméxw (Morrison, 2013). The SRRMC manages and uses this system to assess potential impacts to biophysical and sociocultural heritage (D Schaepe, personal communication, 2017). Developing current and historical baselines of biophysical heritage indicators would be the next step in identifying what aspects of S'ólh Téméxw have been affected by cumulative effects and options for monitoring and safeguarding ecological integrity. The SRRMC is now developing a framework to assess cumulative effects through Stó:lō Connect.

5. Apache case study results

5.1. Cumulative effects

The observations of Apache research consultants ran parallel to published descriptions of climate effects and mostly centered on local aridification. Participants reported observing warmer temperatures, reduced snowfall and rainfall, lower stream flows, and most consequentially, larger and more frequent regional wildfires. The risk of wildfire harms the Tribe's tourism sector as well as recreational and cultural activities during summer fire season (G Lee-Gatewood, personal communication, 2017). Wildfires are also perceived as a personal risk. Participants described the prospect of wildfire evacuations as a source of anxiety and a threat to personal safety (e.g., Alexis, personal communication, 2017).

Local climate aridification may also pose challenges to the Tribe's long-term water supply and food security. Western Apaches traditionally relied on a combination of subsistence agriculture, hunting, and plant gathering (Basso, 1986, p. 3). Decreased precipitation and runoff are leading to difficulties in subsistence farming, less healthy elk and deer populations, and less access to fishing in summer months due to low river water levels (G Lee-Gatewood, personal communication, 2017; L Lacapa, personal communication, 2017). L Lacapa (personal communication, 2017) explained that subsistence agriculture is traditionally based on ditch irrigation. It is seldom viable for subsistence farmers to invest in wells and pumps to water their fields. Participants also perceived traditional plants and medicines to be less available in the territory, probably because of aridification. These plant resources are necessary for traditional ceremonies, such as the Sunrise Dance Ceremony—a puberty ceremony where girls enter adulthood and develop qualities essential for Apache female adult life (Basso, 1986).

5.2. Adaptation actions

Adaptations in the Apache case study include tribal forest management planning and wildfire preparedness, long-term water supply planning, economic diversification, and changes in traditional plants gathering. Forest management involves forest thinning, selective timber harvest, and prescribed and controlled burns to reduce forest density and clear wildfire fuel (G Lee-Gatewood, personal

communication, 2017). Preventative wildfire measures include awareness campaigns that inform tribal members about steps to lower wildfire risk and to prepare for possible evacuations (Alexis, personal communication, 2017). Long-term water supply planning refers to the design and construction of a major dam to boost the Tribe's water supply, among other measures (C Pailzote, personal communication, 2017). Regarding economic diversification, one of the main tribal touristic attractions, a ski resort, is adapting to climate change by diversifying services beyond winter activities to spur year-round tourism and revenue (R Lacapa, personal communication, 2017). Tribal members are adapting to reduced availability of some traditional plants on the reservation by searching outside the reservation and interacting with other tribes in the region (L Lacapa, personal communication, 2017).

5.3. Adaptation constraints and opportunities

Adaptation constraints include insufficient climate awareness, decreased federal government funding, and lack of collaboration on climate adaptation among tribal natural resource departments. Participants perceived insufficient climate awareness in terms of tribal members lacking information about climate change and not recognizing links between global climate change and local effects. According to Apache participants, tribal members seem especially unaware of potential climate change effects to traditional plants:

> *No one in this country says, "How will climate change impact my religious beliefs and practices?" For us, it is going to directly impact our religious beliefs and practices, because we are reliant on environment for those elements. It would be like if in the catholic faith there was a shortage in . . . sacramental crackers and wine, what would you do then? . . . I think that for us we just haven't made that direct correlation. (R Lacapa, personal communication, 2017)*

Participants also identified collaboration and communication deficits at the subtribal level. Participants indicated that departmental segregation, lack of expertise in climate change and adaptation, and insufficient departmental capacity and funding hinder collaborations on climate solutions among natural resource departments (B Pusher-Begay, personal communication, 2017; C Pailzote, personal communication, 2017). It was suggested that increased collaboration among tribal departments would enable more integrated adaptation solutions and resource management planning.

Apache participants emphasized that localized climate education and Apache culture and knowledge perpetuation are needed to enable adaptation. In accord with the results of the Stó:lō case study, these adaptation opportunities comprise reactions to processes that are perceived to decrease adaptive capacity, such as insufficient climate awareness and detriments to Apache cultural traditions and language. Participants indicated that it is important for climate change to be recognized as a culturally relevant issue for tribal members to act upon it (e.g., L Lacapa, personal communication, 2017). Apache participants thus expressed a need for climate education to be aimed at local effects:

> *To hear about climate change, the first thing we think of is in Alaska; the ice is melting. . . . We don't see it at our level, how it is impacting us. It would be good to educate our people. . . . I think that is what is holding the Tribe back. (B Pusher-Begay, personal communication, 2017)*

Regarding Apache cultural perpetuation, Apache language is identified as especially crucial for Apaches to know "who they are"—to the point that one participant mentioned, "the language is gradually dying, and if that happens, the domino effect of total destruction has started" (C Griggs, personal communication, 2017). Participants also underscored that pride in heritage and connections to ancestors can boost adaptive capacity during periods of increased individual or community vulnerability (e.g., G Lee-Gatewood, personal communication, 2017). G Lee-Gatewood (personal communication, 2017) exemplified how these connections can increase youth adaptive capacity and benefit the Tribe:

> *I sit them [students] down and say, . . . "What does the word impossible say to you?" And they are like, "I can't do it". I say, "You can't do it and you can do it. Both of them are true. Which one are you going to be? . . . Your ancestors, they endured, they were strong. . . . You shouldn't have that just going to give up attitude, because that is not what our ancestors were about. You are here to learn, and once you learn, you are going to help your people again."*

Participants also reinforced the view that communities can implement more effective adaptation solutions when relevant traditional knowledge is accessible (Nichols et al., 2004; Turner and Spalding, 2013; Williams and Hardison, 2014). Thus, ensuring that this knowledge is preserved and passed on is crucial for climate adaptation. G Lee-Gatewood (personal communication, 2017) explained how Apache knowledge of wildfire processes has yet to be harnessed to inform and guide wildfire prevention:

> *The way fire works, it does this complete circle [draws map of reservation]. So, in order for that process to finish itself, this part has to someday burn. . . . But if we don't prepare ourselves and prepare the land, then it will be a really big fire and we will lose a lot. Those types of things that come from our elders, the cultural aspect of how things move, that is dying off.*

5.4. Organizational roles

The Fort Apache Heritage Foundation is described as supporting the tribal community through stewardship of the

Fort Apache site, cultural perpetuation and educational services, and tourism and economic development facilitation. The Foundation is promoting Apache culture by facilitating the transition of Fort Apache from a site of military and residential school oppression into an emphatically Apache place that symbolizes and asserts Apache pride and sovereignty (Mahaney and Welch, 2002). Further, the Foundation's role in supporting the Tribe's Cultural Center and Museum is described as a pillar of Apache cultural perpetuation (K Hoerig, personal communication, 2017). Fort Apache's tourism and economic development potential are also relevant for tribal employment and income generation (Ali, personal communication, 2017).

Participants emphasized that the Foundation could further support community adaptation. One such recommendation was to spur climate education projects. Participants suggested that the Foundation invest in youth-led climate education projects to concomitantly encourage localized climate education and youth adaptive capacity. It was emphasized that climate change awareness would ideally integrate climate and environmental education, Apache cultural education, and Apache language (e.g., L Lacapa, personal communication, 2017).

A second recommendation was to integrate climate adaptation into ongoing Foundation practices, such as Fort Apache tenancy and site planning and management policies. The Foundation has integrated environmental stewardship into its Master Plan as a function of heritage perpetuation, thus recognizing intricate interdependencies among land, environment, and culture (Welch, 2019). However, environmental stewardship has not been fully integrated into site planning and policy. R Lacapa (personal communication, 2017) described the incorporation of community goals into planning and policy as an investment with long-term benefits. Recommended next steps include mapping natural and traditional resources around Fort Apache and integrating watershed and resource stewardship into site planning and tenancy policies.

6. Discussion: Supporting climate adaptation of Indigenous communities

We examine similarities across case studies to identify and discuss actions that support climate adaptation of Indigenous communities. The case studies indicate that perpetuation of Indigenous culture and knowledge, increased awareness of local and cultural climate effects, facilitation of community collaboration on adaptation solutions, and mainstreaming of climate adaptation into ongoing organizational services can contribute to adaptation in Indigenous communities.

6.1. Action 1: Perpetuate Indigenous culture and knowledge

Indigenous cultural perpetuation is essential to maintain and revitalize Indigenous relations, practices, and knowledge that have suffered from colonial impacts (Kirmayer et al., 2011). Participants in this project expressed how connections to ancestors, heritage, and territory promote community cohesion and boost adaptive capacity during periods of increased vulnerability. Sydneysmith and Matthews (2011) indicate that, as cultural erosion decreases community resilience, social cohesion, and health, so can cultural identity and connections with the land increase community and household capacity. Sydneysmith and Matthews (2011, p. 25) conclude that elders and elder knowledge comprise the "building blocks" of efforts toward adaptive capacity.

Traditional knowledge stems from a connection with the land and resources and deep understanding of environmental changes. These connections enable community members to perceive environmental changes in their territories and to adapt accordingly (E Victor, personal communication, 2017). Traditional knowledge is prominent in participant comments and viewed as a key to strategic responses to climate change and to empowering individuals, families, and communities to create climate change adaptation tools. At the same time, traditional knowledge and practices have been eroded by colonial processes and face threats stemming from climate impacts to resources needed for their continuation (Downing and Cuerrier, 2011; Turner and Spalding, 2013).

Indigenous views and knowledge can also point to more broadly needed changes in the relationship with nature to restore climatic and environmental balances (Atleo, 2014; Sanderson et al., 2015; Herman, 2016). Some participants see the sources of disconnections between ceremonies and seasonal cycles in human actions as "confusing mother nature" and leading to climatic changes (e.g., C Griggs, personal communication, 2017). Research on climate change perceptions suggests similarities among Indigenous and traditional peoples from diverse cultures and geographies in understanding change in climate as a spiritual and moral phenomenon (Byg and Salick, 2009) in which other-than-human agency reacts to human misconduct (Boillat and Berkes, 2013; Codjoe et al., 2014). Reciprocal relationships must be restored to help prevent and remediate undesired changes in nature: "In Indigenous worldview, if you relate to something on an equal level, it will always be there. If you relate to something like it is less, it stops coming" (E Victor, personal communication, 2017).

Recommendations for Indigenous culture and knowledge to support climate adaptation include identifying, protecting, and promoting knowledge transfers to enable effective adaptation solution tools or mitigate harm to climate-threatened resources. Various Indigenous-led adaptation efforts are likely already implementing these measures, as the role of traditional knowledge is prominent in Indigenous views and climate literature (e.g., Green et al., 2010; Leonard et al., 2013; Turner and Spalding, 2013; Leon et al., 2015; Sanderson et al., 2015; Whyte, 2017). We also recognize that sharing traditional knowledge within and beyond Indigenous communities is not always appropriate and may be justifiably restricted by knowledge holders (Williams and Hardison, 2014; Whyte, 2017).

Our more general finding is that perpetuation of Indigenous culture and knowledge is an essential aspect of community adaptive capacity. Such efforts should make

part of adaptive capacity building and climate adaptation solutions whenever possible. Including Indigenous knowledge holders, community representatives, and traditional stewardship in climate adaptation efforts is the essential basis for fostering respectful recognition and effective deployment of adaptation solutions tailored to cultural and biophysical settings (Maldonado et al., 2016; Whyte et al., 2016; Eira et al., 2018; Makondo and Thomas, 2018). Further, adaptation efforts should acknowledge that traditional knowledge systems may or may not readily harmonize with Western knowledge (Williams and Hardison, 2014; Whyte, 2017; Chisholm Hatfield et al., 2018).

Our last suggestion regarding the use of traditional knowledge is to recognize opportunities for cultural education of non-Indigenous audiences that spur benefits for climate adaptation. As difficulties can arise when integrating traditional and Western knowledge systems for collaborative decision-making (Williams and Hardison, 2014), Indigenous-led cultural education efforts can facilitate adaptation dialogues between Indigenous and non-Indigenous parties. In our study, the SRRMC strives to promote Stó:lō collaboration and reciprocal understanding with non-Stó:lō organizations and governmental bodies, especially through cultural training for staff and visitors.

6.2. Action 2: Provide localized climate information

Climate change awareness is identified as an adaptation enabler across diverse contexts (Klein et al., 2014). Our case studies indicate that improved climate awareness specifically enables adaptation in Indigenous contexts. Other studies engaging with Indigenous communities in Canada and the United States corroborate this finding (Sydneysmith and Matthews, 2011; Gautam et al., 2014; Sanderson et al., 2015). Participants in our study expressed that some community members may lack sufficient climate awareness, may not perceive climate change as a local problem, and may deny anthropogenic climate change. Participants indicated that recognition of climate change as a locally and culturally relevant issue is a prerequisite for community action (e.g., L Lacapa, personal communication, 2017). Climate change can be perceived as "someone else's problem" when people are not informed about its local relevance (Sydneysmith and Matthews, 2011; G Lee-Gatewood, personal communication, 2017).

This study suggests the relevance of engaging with community members to understand their perceptions of climate change. This can simultaneously lead to identification of climate effects not reported in the literature and map gaps in community awareness of local climate effects. When engaging in climate awareness efforts, it is crucial to present this information in ways that are locally and culturally relevant to communities. Further, some participants stressed the importance of considering cultural norms when engaging in educational activities (e.g., L Lacapa, personal communication, 2017)—thus, organizations and collaborators external to communities are strongly encouraged to review the adequacy of climate awareness efforts with community representatives.

More specific recommendations for climate education provided by participants include integrating climate change information into broader topics, such as traditional resource stewardship. This indirect approach can be more effective in Indigenous contexts where climate change is politicized (R Lacapa, personal communication, 2017). Participants in the Stó:lō case study stressed the importance of Indigenous organizations providing climate education opportunities and training for community members who act as community liaisons in adaptation planning (e.g., T Halstad, personal communication, 2017).

6.3. Action 3: Facilitate community collaboration on adaptation

The case studies indicated that climate adaptation may benefit from increased collaboration among community decision-makers and that the participant organizations are well positioned to facilitate communication across community institutions. This study suggests that cooperation may be insufficient due to community division as a product of colonial policies, lack of financial and administrative resources for joint decision-making, and departmental segregation. Participants suggested that Indigenous organizations can support community adaptation by acting as channels of communication and facilitating cooperation across Indigenous communities and decision-makers. Such efforts are expected to provide opportunities to identify common solutions to shared impacts and to efficiently employ scarce assets for adaptation. More generally, participants suggested that increased cooperation would further empower communities that share a traditional territory to support each other in asserting rights, pursuing common interests, and adapting to common challenges.

Study results recommend that external parties engaged in climate adaptation with Indigenous communities place special attention on existing Indigenous institutions and protocols, so as not to foster divisiveness among Indigenous peoples by solely following settler understandings of jurisdictions, geographies, and institutions when conducting or funding adaptation efforts. As explained by M Ned (personal communication, 2017):

> *I will use one example. There are 30 First Nations in the Lower Fraser. Fisheries and Oceans Canada has broken that down into subregions. So they might manage a few of the Stó:lō nations over here and they might manage a few of the Stó:lō nations over there in terms of access to fish. That in itself starts to divide the communities, so that is what we need to be cognizant of. . . . We have adapted to their systems. So how do we reeducate ourselves back to traditional practices? Which are more collaborative and collective.*

6.4. Action 4: Mainstream climate adaptation into ongoing programs, policies, and planning

Finally, participants in both case studies indicated that the participant organizations hold unrealized potential to mainstream climate adaptation into ongoing organizational programs, policies, and plans. The literature indicates that mainstreaming or integrating climate

adaptation goals into existing policies and projects has advantages relative to developing initiatives exclusively focused on climate adaptation (Runhaar et al., 2018). For example, mainstreaming adaptation often makes for more efficient use of technical and financial assets than investing in adaptation projects unrelated to ongoing programs (Bouwer and Aerts, 2006).

The case studies indicated that the participant organizations—which are not primarily dedicated to climate adaptation but to cultural heritage stewardship—are actively improving the adaptive capacity of their communities and hold potential to further support community adaptation, especially through efforts that integrate climate adaptation into ongoing programs and policies. Thus, we conclude that Indigenous organizations at large may be well positioned to assist their communities with climate adaptation and that engaging with community members is a fruitful way to explore how existing programs can support the community in adapting to ongoing and projected climate effects. Similarly, we suggest that non-Indigenous parties involved in climate adaptation in Indigenous contexts engage with existing organizational capacity at the community level. Engagement with local capacity can identify ways for climate adaptation to be mainstreamed into ongoing programs and simultaneously strengthen community capacity.

7. Conclusion

Climate change effects are projected to increasingly threaten traditional territories, waterways, and resources vital to Indigenous well-being and cultural continuation (Maldonado et al., 2013; Jantarasami et al., 2018). It is essential to boost adaptive capacity and adaptation efforts of Indigenous communities to mitigate ongoing and projected climate effects. Even though colonial disruptions continue to hamper Indigenous adaptive capacities, this study suggests that Indigenous-owned organizations can support community adaptive capacity to climate change. Findings from the case studies suggest that Indigenous communities benefit from services that help perpetuate Indigenous culture and knowledge, that provide climate change information tailored to local environments, and that facilitate collaborative decision-making on climate adaptation. Further, Indigenous organizations likely possess underutilized potentials to mainstream climate adaptation into projects and activities, including capacity creation, policy development, and land use planning and restoration.

More generally, it is also important to note that the recognition of Indigenous voices and rights is integral to the perpetuation of Indigenous cultures, communities, and traditional environments (Etchart, 2017). Place-based adaptation is contingent on broader contexts of relationships between Indigenous peoples and settler societies. As such, harmonization of settler legislation with the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) is vital for local adaptation efforts to be successful—for example, BC has enacted the *Declaration on the Rights of Indigenous Peoples Act*, which sets in motion a process to review legislation according to UNDRIP.

This study's limitations include a bias toward North American Indigenous contexts. Indigenous communities in developing countries likely experience different sets of adaptation opportunities and constraints. Within a North American context, access to more community case studies would help determine whether the identified actions are universally agreed upon or are dependent on cultural or climatic contexts (or both). Further, within the studied communities, certain perspectives may have been neglected due to the organizational focus of the research. Future research could address these gaps and provide additional Indigenous perspectives on the crucial and understudied issue of adaptation solutions for projected climate scenarios in Indigenous contexts.

Data accessibility statement

The semi-structured interview guide used to collect data for this project is available as a Supplemental Material (S1). This research was approved by Simon Fraser University's Office of Research Ethics (Study Number 2017s0186). In accordance with our participant consent protocol and with Stó:lō Nation/SRRMC interview protocols and policies addressing Stó:lō intellectual properties, data collection, use, and sharing, we are not publishing our raw interview data.

Supplemental file

The supplemental file for this article can be found as follows:

Text S1. Semi-structured Interview Guide. Docx

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Competing interests

The authors have no competing interests to declare.

Author contributions

- Contributed to conception and design: VHG, DMS, JRW.
- Contributed to acquisition of data: VHG, DMS, JRW.
- Contributed to analysis and interpretation of data: VHG, JRW.
- Drafted and/or revised the article: VHG, DMS, JRW.
- Approved the submitted version for publication: VHG, DMS, JRW.

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