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# The Kake Climate Partnership: Implementing a knowledge co-production framework to provide climate services in Southeast Alaska

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This paper provides a case study analysis of knowledge co-production with an Indigenous community and Tribe in Southeast Alaska. The 24-month study provided climate services and information in support of climate adaptation and mitigation with community identified priorities of food sovereignty and food security. Our objectives are to (1) describe an application of a theoretical framework that is specific to co-production among Indigenous and non-Indigenous partners, and (2) reflect on the ways in which this application supports relevance and use of climate services in an Indigenous community. Methods included text analysis of written research logs, review of monthly project briefings and structured discussions among a diverse author team. We found that co-production can be used to explicitly define a collective vision among partners that is a transformative way of doing applied climate and environmental science. As such, the role of the university researcher shifted from focusing on personal research interests to a focus on supporting local needs and priorities. When the climate services process is centered on Tribal and community priorities and locally identified science needs, the climate science aspect becomes just one element in the implementation of a larger local vision and goals. Challenges our team encountered during the study were related to logistics, communication, juggling priorities of multiple partners, capacity, and conducting community-based research during a global pandemic. We recommend that future efforts to co-produce climate services through research, adaptation planning, and mitigation be institutionalized and maintained over decadal, not annual, timescales.

KEYWORDS

**co-production, Southeast Alaska, research partnerships, Indigenous Knowledge, Traditional Knowledge, learning network, climate services, climate change**

## Introduction

The field of climate services emerged to better equip decision-makers with tools to manage the risks and opportunities arising from climate variability and climate change (National Research Council, 2001; Solomon et al., 2009; Hewitt et al., 2012; Brasseur and Gallardo, 2016; Daly and Dilling, 2019). Climate services are science approaches that focus

on the usefulness, usability, and practical applications for climate change adaptation planning and mitigation (Brooks, 2013). Increasingly, co-production is acknowledged as a valuable mechanism for providing climate services (Vincent et al., 2018, 2020; Steynor et al., 2020; Vollstedt et al., 2021). Co-production can support the generation of climate services that are contextually credible, salient, legitimate (Buontempo et al., 2014; Bremer et al., 2019), and which go beyond the provision of climate information to support procedural benefits, including local empowerment (Baztan et al., 2020).

Co-production approaches are increasingly acknowledged as beneficial to actionable science in support of climate adaptation (Homsy and Warner, 2013; Meadow et al., 2015; Lavorel et al., 2020), and offer the opportunity to carry out climate research that uses meaningful methods to produce useful results for the public (Inukalik et al., 2020; Latulippe and Klenk, 2020; Yua et al., 2022). While there is a growing body of literature that describes characteristics of meaningful co-production (Beier et al., 2017; Wall et al., 2017b; Yua et al., 2022), processes of implementing (Djenontin and Meadow, 2018; Austin et al., 2019; Sikuaq Erickson, 2020) and evaluating (Wall et al., 2017b) co-production are not as prevalent.

Climate change is impacting the land and resources that Indigenous communities and Tribes in Alaska rely on for food security, food sovereignty, resource management, and cultural continuity, all of which are important Tribal and community priorities (ICC, 2012; Inukalik et al., 2020). Concurrently, Indigenous leaders are speaking out against the inequities in scientific research that have benefitted the scientific enterprise but left communities without tangible solutions to the challenges they face (Bahnke et al., 2020; Early, 2021). When climate science and adaptation planning are led by communities and Tribes, research and adaptation outcomes have the potential to be locally relevant (Kipp et al., 2019). Indigenous-led research can enable prioritization of Indigenous connections between the environment and wellbeing (Kipp et al., 2019). Indigenous peoples may be well positioned to use Traditional Knowledge in climate science and to inform adaptation planning, given historical and lived experience with adaptation and worldviews that promote holistic problem-solving (Vogel and Bullock, 2021). Conducting science with Indigenous methodologies and worldviews is a growing field (CTKW et al., 2014; TallBear, 2014; Johnson et al., 2016; Maldonado et al., 2016; Daniel, 2019; David-Chavez et al., 2020) and a model of knowledge co-production has been presented by Indigenous leaders in Alaska (Yua et al., 2022).

While co-production is widely put forward as a desired process for creating use-inspired science (Beier et al., 2017; Wall et al., 2017a; Wyborn et al., 2019; Norström et al., 2020), co-production among non-Indigenous researchers and Indigenous communities requires special considerations (David-Chavez and Gavin, 2018; Carlo, 2020; Sikuaq Erickson, 2020). Meadow et al. (2015) note a need "to refine our understanding…of what specific actions and activities most effectively produce the trusting, long-term relationships necessary to the co-production of usable science" (p. 189). In this paper, we present the specific actions and activities our team carried out while forming effective relationships to co-produce meaningful climate science among Indigenous and non-Indigenous partners in Southeast Alaska.

This paper presents an instrumental case study (Stake, 1995) of knowledge co-production with an Indigenous community and Tribe in Kake, Southeast Alaska, aimed at providing climate services (Brooks, 2013) in support of climate adaptation and mitigation. Our **objectives** are to (1) describe an application of the Yua et al. (2022) co-production framework (hereafter, Ellam Yua co-production) in the Kake Climate Partnership, and (2) reflect on the ways in which our application of Ellam Yua co-production is linked to the relevance and use of climate services in an Indigenous community.

For Objective (1), we documented our experiences over the first 24 months of our research partnership through tracking:

> *(1a) Accomplishments and financial spending over 24 months,* to better understand the potential repeatability of implementing Ellam Yua co-production in climate change research.
> *(1b) How the Ellam Yua co-production elements manifested in our work,* to compare our work with the ideal type of Ellam Yua co-production.
> *(1c) Challenges faced during the 24-month period of study,* to inform others who may choose to implement Ellam Yua co-production and provide a balanced analysis of our application of the framework.

For Objective (2), we present details about key features of the Kake Climate Partnership. We use the term 'study' throughout this paper to refer to our case study research of the co-production process.

# Materials and methods

## Co-production of knowledge

Jasanoff (2004) and others (e.g., Miller, 2004) use the term co-production broadly to mean how, "the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it" (p. 13). In a review of publications using co-production, Bremer and Meisch (2017) found no "common view of co-production" in climate research, and instead classify co-production in climate research across eight different lenses, or approaches. However, in climate and environmental sustainability research, it is common to encounter an outcomes-based understanding of co-production (Dilling and Lemos, 2011; Meadow et al., 2015;

Lemos et al., 2018; Kettle, 2019). For example, Lemos et al. (2018) discuss co-production as, "a focus of research and…practice among scientists, stakeholders, and funders" (p. 722), situated in terms of how well it can lead to sustainability outcomes for society. Daly and Dilling (2019) describe a focus on outcomes as a normative approach to co-production.

Although co-production practices are increasingly popular, Daly and Dilling (2019) found that normative co-production practices do not necessarily lead to transformational or usable climate services. Treating co-production as a means to an end, rather than a meaningfully reflexive process, can reinforce existing power imbalances and inequities without producing relevant or applicable climate services. In contrast to normative co-production, the Ellam Yua co-production framework we employed for this study is process-based (Figure 1).

### Selecting a framework: Ellam yua co-production

We use the Ellam Yua definition of knowledge co-production, which is a "process that brings together Indigenous Peoples' knowledge systems and science to generate new knowledge and understandings of the world that would likely not be achieved through the application of only one knowledge system" (p. 2). Ellam Yua co-production involves 21 elements depicted in Figure 1.

Ellam Yua co-production was selected for this study because this framework was developed by Indigenous scholars in Alaska, for work among Indigenous and non-Indigenous Alaskans, and explicitly engages a holistic, Indigenous worldview (Daniel, 2019; Yua et al., 2022; Figure 1).

Tribal sovereignty—the authority to self-govern (NCAI, 2022)—is a central concept in Ellam Yua co-production. Following Ellam Yua, meaningful co-production takes place when Indigenous and non-Indigenous partners lead a project together from the beginning stages of developing a research idea through project design, data collection and analysis, and sharing of project outcomes, while upholding Tribal and data sovereignty (NCAI, 2018; Latulippe and Klenk, 2020). Creating and nurturing an equitable and meaningful process among partners is as important—and sometimes more important—than specific research or sustainability outcomes. It is expected that by focusing on an equitable process, outcomes will be relevant to and useful for Tribal and community partners.

Ellam Yua co-production aligns with epistemologies aimed at centering equity, ethics, and decolonization—disrupting legacies of imperialism and exploitation (Tuhiwai Smith, 2012; Marino et al., 2020)—across fields of study and policy (Bartlett et al., 2012; Tuck and Yang, 2012; Fryberg and Eason, 2017; Latulippe and Klenk, 2020; Reid et al., 2021), as well as specifically in climate change research (Mihlar, 2008; Whyte, 2013, 2017). Ellam Yua co-production shares characteristics with "Two-Eyed Seeing", as described by Bartlett et al. (2012) and Reid et al. (2021), in that both aim to weave together Indigenous and non-Indigenous knowledge systems. Ellam Yua co-production has similarities with some work in the realm of participatory action research (Peterson, 2011), political economy focused on climate vulnerability (Barnett, 2020), "transformative" worldview approaches to social science (Creswell, 2014), and other co-production approaches (Turnhout et al., 2020; Hauser et al., 2021), which are similarly centered in power- and justice-oriented scientific research.

## Geographic area, research partners, and related activities

### Land acknowledgment

As authors of this paper, everywhere we live and work is Native land. We recognize, appreciate, and honor Indigenous peoples and their past, present, and future land stewardship. The work we present in this paper has taken place on the unceded territories of many Indigenous peoples within the boundaries currently recognized by the United States Federal government as the State of Alaska. Most of our field research work has taken place on Tlingit Aani, in the unceded territories of the Keex' Kwaan Tlingit people in Southeast Alaska (Figure 2).

### Geographic area: Kake, Alaska (Keex' Kwaan)

Kake is in the heart of Southeast Alaska, at the confluence of three major bodies of water: Frederick Sound, Chatham Strait, and Keku Strait (Figure 3). Kake is a Tlingit Alaska Native community in Southeast Alaska with a population of around 570 people (US Census 2018) and is accessible by boat or small plane. Kake is not accessible by road from other communities in Alaska, the contiguous United States, or Canada. The State of Alaska designates the community of Kake as encompassing 12.85 square miles of land on the northwest shoreline of Kupreanof Island (DCRA, 1988; Supplementary file A). The Organized Village of Kake Federally recognized Tribe recognizes an overlapping but much larger area of land and water as the traditional Kake Community Use Area for people in Kake (Figure 2).

Like other areas of Southeast Alaska, the coastal rainforest area surrounding the Kake Community Use Area is comprised of steep walled valleys and deep, narrow bays characteristic of glaciated terrain (CEC, 2015). Southeast Alaska has the mildest temperatures in Alaska, and typically experiences large amounts of precipitation year-round. Historically (1925–2021), monthly average temperatures have ranged between 16.6 and 59.6 degrees Fahrenheit and monthly precipitation has ranged between 0.41 and 27.97 inches in the area surrounding Kake (NOAA, 2022a,b). The forests are dominated by western hemlock and Sitka spruce and the coastal ocean waters are heavily influenced by glacial runoff (Gallant et al., 1995).

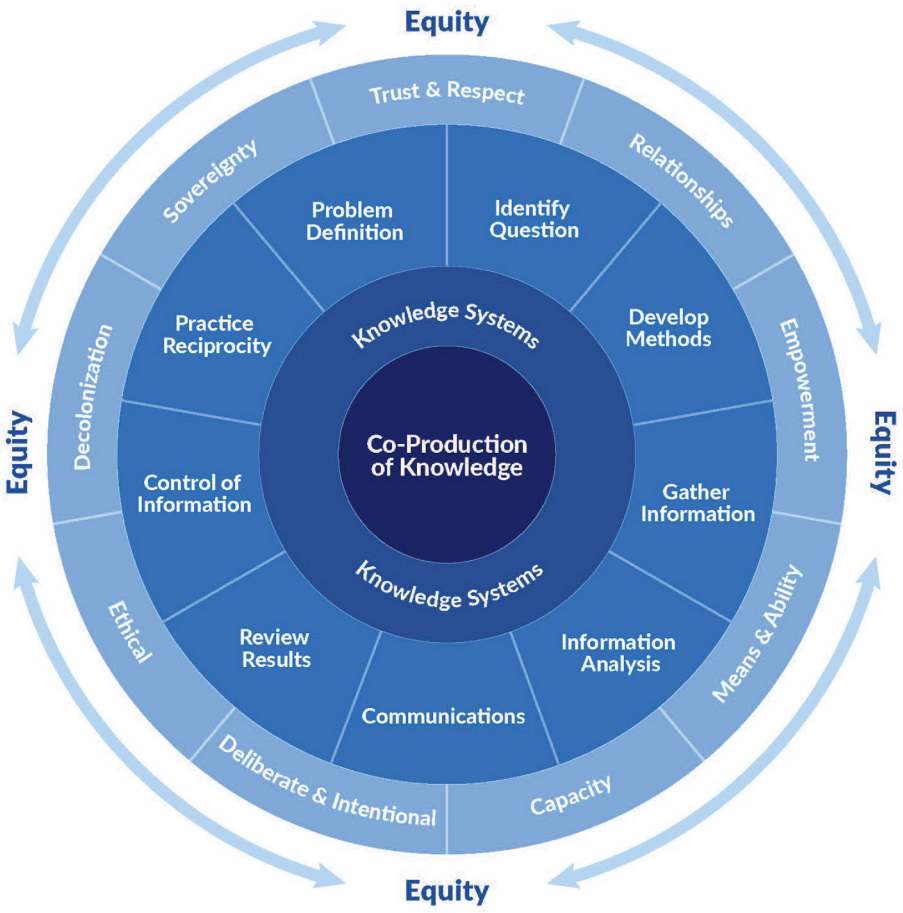




FIGURE 1
Reproduced from Yua et al. (2022) depicting a visual representation of the framework for Ellam Yua co-production of knowledge (CPK). Yua et al. (2022) explain: "The center of the framework shows the goal: co-production of knowledge. Surrounding the goal are the two knowledge systems (Indigenous Peoples' knowledges and science) that will come together in this process. The inner ring surrounding the knowledge systems is what we refer to as the "action circle." This circle, or inner ring contains various aspects of, or actions that are part of, a CPK research process. We emphasize that CPK is a process. The outer ring of the CPK framework holds all the concepts, referred to as "conceptual tools," that all participants in this approach need to implement and be continuously mindful of. These tools are the concepts that, when implemented together, can bring about equity. Lack of equity is a systemic issue in many research relationships with Indigenous Peoples. Without equity, a CPK approach is not possible. CPK is an iterative and cyclical process, rather than a simplistically linear approach" (p. 9).

Climate change impacts in Kake and throughout Southeast Alaska include increasing variability and extremes in weather events. For example, while annual precipitation in the region is increasing over long timescales, year to year fluctuations have led to extreme drought periods in recent years (e.g., 2017–2019; Thoman et al., 2019). Increasingly unstable weather patterns, including seasonal drought conditions, have led to large variations in stream depth and temperature and concerns about the potential for increasing harmful algal bloom incidence in ocean waters near Kake (Leffler, 2019). The long-term health of ocean water, creeks, and streams around Kake directly affect Tribal and community health, food sovereignty (Inukalik et al., 2020), and food security (Carlo, 2020; Inukalik et al., 2020) of local residents through impacts on foods like seaweeds, shellfish, and fish, including salmon. Linkages among climate change, the environment, and pollution are locally relevant, as they have potential to impact food sovereignty and food security through impacts to accessing healthy customary and traditional foods throughout the Kake Community Use Area.

## Research partners and related activities

The Kake Climate Partnership (the Partnership) was formed in 2020 between a Federally recognized Tribe, a local Tribal corporation, a rural municipal government, and a research and boundary spanning (Kettle and Trainor, 2015) organization at a

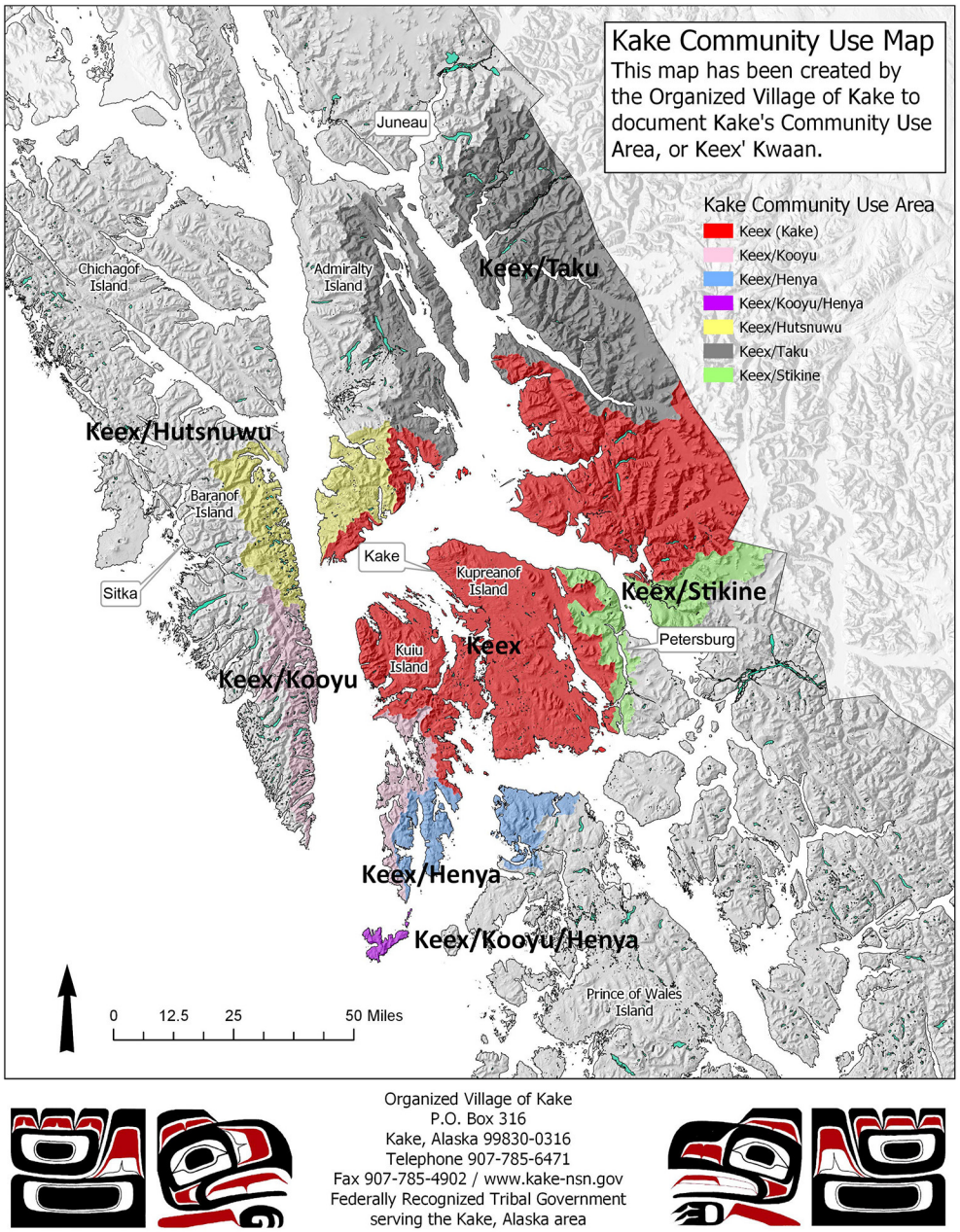


FIGURE 2
Kake Community Use Map, depicting traditional harvest areas for members of the Organized Village of Kake Tribe and residents of the community of Kake. Core Keex' Kwaan Customary and Traditional Use areas and shared areas total over 6,000,000 acres. This is a map that was created by Mike Ka.oosh Jackson (OVK Historian) and Bob Christensen (ESRI GIS Mapper).

public university: the Organized Village of Kake (OVK), Kake Tribal Corporation (KTC), the City of Kake (the City), and the Alaska Center for Climate Assessment and Policy (ACCAP) at the University of Alaska Fairbanks (Table 1). The Tribal, Tribal corporation, and municipal partners are based in the community of Kake, while the university partners are based in Juneau, AK, (E. Figus) and Fairbanks, AK (S. Trainor). All research projects carried out by the Partnership take place in and around Kake.

The Climate Partnership was modeled after the existing Keex' Kwaan Community Forest Partnership (Nix, 2019) and is aligned with broader work to strengthen food sovereignty and security and manage natural resources in the Kake Community Use Area. There are existing initiatives in Kake for a Tribal

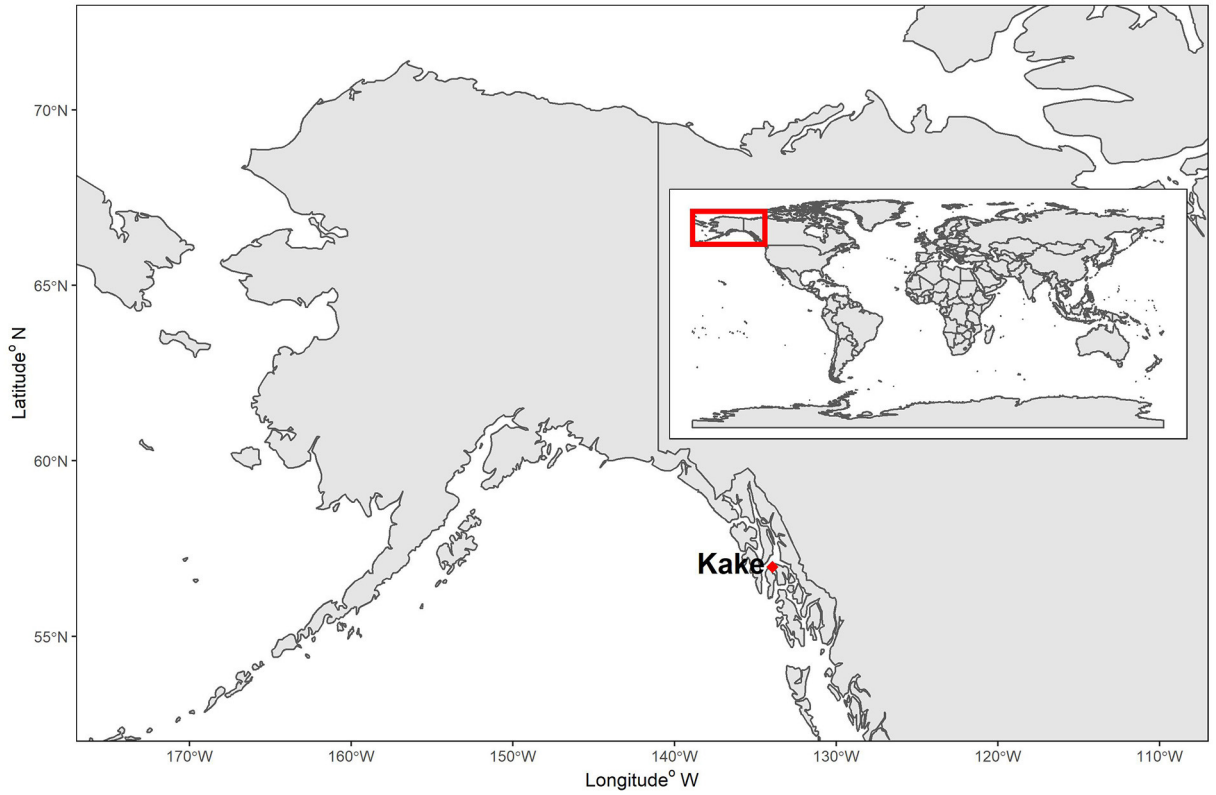


FIGURE 3
Alaska in relation to Earth, and Kake in relation to Alaska. Created by M. Rhodes-Reese in Adobe Illustrator.

Conservation District and an Indigenous Coastal Guardian Network. In 2018, OVK began pursuing status for the Kake Community Use Area to become a Federally recognized Tribal Conservation District (TCD; NRCS, 2020)[1]. Status as a TCD provides eligibility to apply for funding support from 22 departments within the United States Department of Agriculture to monitor and protect the TCD area. OVK and KTC agreed to sign an MOU with the USDA to form the Keex' Kwaan Tribal Conservation District. In November of 2021, the MOU forming the Keex' Kwaan Tribal Conservation District was signed by the United States Secretary of Agriculture (USDA, 2021). The Tribal Conservation District is described in greater detail in Table 2.

OVK is part of a growing movement aimed at creating an Indigenous Coastal Guardian Network in Southeast Alaska, modeled after an existing Guardian Watchmen program across the North Pacific Coast, to "uphold and enforce traditional and contemporary Indigenous laws...in protecting and managing coastal territories" (CFNGBI, 2022a). The Coastal Guardian Network is described in more detail in Table 2. Creation of the Keex' Kwaan Tribal Conservation District and a Coastal Guardian Network program in Southeast Alaska have the potential to support greater local and Tribal sovereignty to manage natural resources and exercise authority over climate change adaptation planning and mitigation in the Kake Community Use Area.

## Instrumental case study

We use an instrumental case study (Stake, 1995) analytical approach in this paper to address both Objective (1) and Objective (2). In this application, the Kake Climate Partnership is treated as a "program" (Stake, 1995) studied to learn about the "process" of Ellam Yua co-production. Co-authors on this paper brought three different perspectives to this work. During the study, E. Figus was a university research center postdoctoral fellow with full-time work capacity devoted to the Partnership. E. Figus was a non-objective (see Stake, 1995, p. 8) participant observer in the study, who simultaneously recorded and examined meaning of Kake Climate Partnership activities during the study period. B. Ki'yee Jackson was a Kake resident, an enrolled member of OVK Tribe, a shareholder in KTC, and was a full-time staff member at OVK with part-time work capacity devoted to the Partnership throughout the 24-month period of this study. S. Trainor was a co-Director of the ACCAP

1 B. Ki'yee Jackson personal observation, 2021.

TABLE 1 Description of each entity in the Kake Climate Partnership, including their primary role in the Partnership.

**Description of Kake climate partnership member entities**

| Partner member | Member information | Participation in the co-production process |
|---|---|---|
| Organized Village of Kake (OVK) | OVK is one of 229 Tribes within the State of Alaska recognized by the United States Federal government (BIA, 2022). and makes decisions via its Indian Reorganization Act (IRA) Council. OVK had 1,002 enrolled tribal members as of February 2022. | OVK IRA Council members, members of OVK staff, and enrolled members of the OVK Tribe all participate in designing and carrying out the partnership field projects. Updates on the Kake Climate Partnership are presented monthly at OVK meetings. |
| Kake Tribal Corporation (KTC) | KTC is the for-profit Alaska Native village corporation in Kake. Created by the Alaska Native Claims Settlement Act (ANCSA) of 1971, KTC owns land in the vicinity of Kake (Supplementary file A). KTC had 748 shareholders as of March 2022. | KTC makes decisions *via* a Board of Directors. KTC Board members, members of KTC staff, and KTC shareholders all participate in designing and carrying out the partnership field projects. |
| City of Kake (the City) | The City of Kake is a First-Class City in the unorganized Wrangell/Petersburg Borough (ADCCED, 2015). It functions as the municipal authority for the community and makes decisions *via* regularly held meetings of their City Council. | The City Council votes on key aspects of the Kake Climate Partnership and individual members of the City Council and City staff participate in designing and carrying out the Kake Climate Partnership field projects. |
| Alaska Center for Climate Assessment and Policy (ACCAP) | ACCAP is a Regional Integrated Sciences and Assessments (RISA) program funded by the Climate Program Office at the National Oceanic and Atmospheric Administration (NOAA; NOAA, 2022c). ACCAP is housed in the International Arctic Research Center at the University of Alaska Fairbanks and conducts innovative and collaborative research and engagement to inform climate policy, decision-making, and action for a just and sustainable future. | ACCAP serves as a boundary spanning organization for the Kake Climate Partnership, providing organizational, logistical, and scientific support. |

*(Continued)*

TABLE 1 Continued

RISA program in Alaska with connection to the Partnership *via* her role as E. Figus supervisor throughout the 24-month period of this study.

## Building a partnership through written and agreed upon principles and expectations

In December 2019, E. Figus contacted OVK, KTC, and the City of Kake to propose a climate research partnership using the Ellam Yua co-production approach. In January of 2020, the OVK Council passed a resolution to partner with E. Figus and ACCAP, and to extend a partnership invitation to KTC and the City. In May of 2020, all four potential partners held a joint meeting virtually *via* Zoom video conferencing software (Banyai, 1995) to discuss whether and how to finalize a broader partnership. At the meeting, ACCAP, OVK, KTC, and the City created a set of explicit Principles and Expectations (following Naquin et al., 2019; Supplementary file B) to guide the work of the Partnership. The Principles and Expectations document stipulates broad ideas (e.g., shared values among partners) and narrowly defined responsibilities (e.g., who is responsible for record-keeping). The KTC Board of Directors and the City Council subsequently passed resolutions to formalize the Kake Climate Partnership during the summer of 2020.

## Travel

Following Ellam Yua co-production elements in the 'Conceptual Tools' and 'Action Circle' rings of the model (Figure 1), E. Figus traveled to Kake in person early and often in this process, spending a total of 10.5 weeks in Kake during this study. E. Figus made four short trips to Kake between December 2019 and March 2020, before needing to

TABLE 2 Detailed descriptions of two ongoing activities in Kake related to the Kake Climate Partnership.

**Descriptions of two activities in Kake related to the Kake climate partnership**

| Related activity | Description |
|---|---|
| Keex' Kwaan Tribal Conservation District | A Tribal Conservation District (TCD) is an area of traditionally Tribal land that is managed through a Memorandum of Understanding (MOU) between a Federally recognized Tribe and the United States Department of Agriculture (USDA; See text footnote 1). "*The goal of tribal conservation districts is to set local priorities for conservation and ensure sustainable use of natural resources for subsistence, economic opportunity, resource development, and cultural preservation*" (NRCS, 2020). *"[A] TCD has the Traditional Knowledge*; [the] *USDA has the assistance, funds, [and] experience to help with technical needs*" (ATCA).<br>A Tribal Conservation District MOU may include the local ANCSA corporation with lands overlapping a traditional Tribal area. In Oct 2021, OVK and KTC created an MOU with the USDA to create a TCD in Kake.<br>The Board of Directors for the Keex' Kwaan Tribal Conservation District will include members from both OVK and KTC. |
| Southeast Alaska Coastal Guardian Network | Modeled after an existing Guardian Watchmen program across the North Pacific Coast, the Indigenous Coastal Guardian Network in Southeast Alaska, is a growing movement focused on: *ensuring resources are sustainably managed, that rules and regulations are followed, and that land and marine use agreements are implemented effectively. . . They uphold and enforce traditional and contemporary Indigenous laws and continue the work of their ancestors in protecting and managing coastal territories* (CFNGBI, 2022a).<br>The Nature Conservancy describes Coastal Guardians in Alaska as a network to: *support community land and resource stewardship by connecting existing local programs, aspiring community leaders and natural resource managers. The network provides technical and social support to strengthen community-based stewardship region-wide* (Woll, 2018).<br>The Coastal First Nations Great Bear Initiative explains that: as *Indigenous peoples we derive our authority and jurisdiction from our traditional laws to manage and safeguard the lands and waters of our territories for the health of future generations* (CFNGBI, 2022b). Work to implement the Indigenous Coastal Guardians Network in Southeast Alaska has been led by the Sustainable Southeast Partnership, of which OVK is a leading member (Woll, 2018). |

pause travel for 6 months due to the onset of the COVID-19 pandemic. During those first four trips to Kake, E. Figus was able to present in person at meetings of the OVK IRA Council, the Kake City Council, and at the Annual Meeting of the OVK Tribe, as well as meet individual members of the KTC Board in person. In addition, E. Figus and OVK staff worked with the teachers and administrators at the Kake City Schools to provide guest lectures and an intertidal field trip for middle and high school students in Kake in January and March of 2020, respectively. E. Figus subsequently made two three-week trips to Kake (to allow for quarantine periods), in October 2020 and March 2021, and made three short trips to Kake (when quarantine was not needed) in May and September 2021.

## Determining field projects

Field research topics were determined by partners from Kake using consensus to choose a set of projects to work on together. During the spring of 2020, OVK, KTC, and the City held informal meetings to discuss ideas for climate change field projects and ACCAP partner E. Figus documented the various ideas (Supplementary file C). At the formal joint meeting in May of 2020, E. Figus presented the lists of potential projects, and all partners agreed on which of the ideas to prioritize.

## Funding for field projects

Because the field projects were determined through the co-production process, leveraging existing funds and securing new funds to support project costs took place during the study. Members of the Kake Climate Partnership carefully tracked their spending related to their co-production process as well as to individual field projects. We provide a general overview of the financial spending associated with the Partnership in later sections of this paper.

## Documenting the partnership and process

Co-author (and ACCAP employee) E. Figus was the only partner with full-time work capacity devoted to the Partnership. Therefore, the bulk of the documentation responsibilities were placed on her. We documented our partnership and our co-production processes in three ways:

1. Written Logs: Co-author E. Figus kept written logs between November 2019 and October 2021, to document Partnership activities and specific reflections about the co-production of knowledge process (Supplementary file D). Li (2018) notes, "reflexivity is an important research device for the social construction of new knowledge and production of competent research identities" (p. 17). In

line with Li (2018), the written logs allowed for *self-reflexivity* (Alvesson and Skoldberg, 2009) and a process of *self-questioning* about methodological, theoretical, and practical issues (Silverman, 2010; Li, 2018) by the primary university partner throughout the study.

2. Written monthly updates: E. Figus prepared monthly update briefings between May 2020 and October 2021, which were emailed to all project partners.

3. Reflective conversations among co-authors: Co-authors met four times for a period of 1 h each during the Fall of 2021 to discuss our observations and experiences over the 24-month period. Co-authors E. Figus and B. Ki'yee Jackson further met weekly during the Fall of 2021 for 30–60 min each, to discuss the study. Reflective conversations added *collaborative reflexivity* (Alvesson and Skoldberg, 2009) to this work. These conversations were important because they provided a diversity of perspectives as well as important space for all co-authors to share observations and perspectives and ensure those were documented in this paper. Co-author E. Figus documented these conversations in written notes, and all three co-authors used those notes to reach consensus about key outcomes from the study.

## Analysis

*Objective 1: describe an application of the Yua et al. (2022) co-production framework.*

In documenting our partnership and processes we tracked items (1a), (1b), and (1c). Analyses for each item are described below.

*(1a) Accomplishments and financial spending over 24 months.*

Co-authors reviewed monthly project updates and the Principles and Expectations document and used reflective conversations to summarize accomplishments of the Kake Climate Partnership. Accomplishments during the study are organized in relation to our shared set of Principles and Expectations.

We summarized our approximate spending across each of 3 broad categories: Travel, Salary/Direct Payments, and Field Project Costs. The category "Travel" includes only travel by E. Figus to Kake, as other travel was canceled during the 24-month period of the study, due to the COVID-19 pandemic. The category "Salary/Direct Payments" refers to E. Figus's salary, partner staff time, and payments to local residents in Kake for work related to the Partnership. The category "Field Project Costs" includes purchase of supplies, shipping, sample processing, and any direct payments to people not residing in Kake who assisted with Partnership work during the 24-month period.

*(1b) How the Ellam Yua co-production elements manifested in our work.*

*(1c) Challenges faced during the 24-month period of study.*

Responses to items (1b) and (1c) were determined through analysis of written logs and reflective conversations among co-authors. Monthly logs were written and analyzed by project facilitator, E. Figus, and were coded based on intentions and outcomes. For example, use of the code 'Equity', could refer to an intent to create equity or an outcome of equity. Coding was not split between these two perspectives. This approach to coding was made possible because the coder was the same person who had written the log entries. The dual role of researcher and practitioner played by E. Figus may have caused added 'strain' for her lived experience during the study (Arber, 2006), but this reflexive activity enabled us to gain awareness of how the study and relationships developed within it shaped both the researcher (E. Figus) and the research (the Kake Climate Partnership).

Written logs were analyzed in the NVivo text analysis software program (QSR International Pty Ltd., 2020) using both deductive and inductive coding (Bernard, 2011). Deductive codes are determined prior to analysis and are used to test a hypothesis or seek out predetermined themes in a text. Inductive codes are identified during the coding process and are used to allow themes and understanding to emerge from a text without predetermined ideas. Individual logs for each of the 24 months from November 2019 through October 2021 were uploaded to a single NVivo file. A total of 22 deductive codes were created at the beginning of the text analysis process. Twenty-one of the codes correspond to elements in the Ellam Yua co-production framework (Figure 1), and one code was created for "Challenge", specifically to capture information relevant to item (1c). We use the term "elements" throughout this paper to refer to the 21 pieces of the Ellam Yua co-production framework (Figure 1) as defined by those authors. The code for "Challenge" was defined as difficult tasks or problems our team encountered, including caveats and deviations from Ellam Yua co-production. The code for "Challenge" was analyzed alongside the Ellam Yua elements and is described with them in the section titled, "Results from coding monthly logs."

Additional codes were created inductively during the coding process, which were not part of the Ellam Yua framework. Deductive codes were subsequently analyzed in the NVivo software program for incidence, clustering using Pearson's and Jaccard's correlation coefficients (Egghe and Leydesdorff, 2009), and qualitative characteristics. Qualitative themes were explored in the inductive codes and correlation analyses were not run on them. The content of the codes was summarized to respond to (1b) and (1c). Coding results were visualized using NVivo software. Selected quotes were also chosen from the logs to aid in descriptions throughout the paper.

*Objective 2: reflect on the ways in which our application of Ellam Yua co-production is linked to the relevance and use of climate services in an Indigenous community.*

We used collaborative reflexivity (Alvesson and Skoldberg, 2009) in the form of reflective conversations among co-authors to build upon findings from our analysis of items (1a), (1b),

TABLE 3 Abbreviated list of principles and expectations of kake llimate partnership with examples of how each one was accomplished during the 24-month period of this study.

**Abbreviated list of principles and expectations of Kake climate partnership with examples of how each one was accomplished**

| Principle | Meaning | Example during this study |
|---|---|---|
| Southeast traditional tribal values | Members acknowledge and respect the values established by the regional tribal government in Southeast Alaska (Central Council; CCTHITA, 2019). | The Southeast Traditional Tribal Values are at the forefront of all actions in the Kake Climate Partnership. |
| Respect and equity | This work should set an example of respectful, equitable research between a Tribe, a City, a Tribal Corporation, and a university. | Building a partnership centered around respect and equity was an iterative and ongoing process throughout the 24-month period of this study. |
| Food sovereignty | All parties acknowledge that food security and food sovereignty is a key value and should play a role in all aspects of this work. | All research projects characterize impacts of climate variability and pollutants on traditional foods. |
| Knowledge and wisdom of elders | This work aims to learn from elders through respectful documentation of their knowledge. | Partners planned a Traditional Knowledge documentation project with Elders in Kake. |
| Data sovereignty | Data sovereignty for the Tribe and individuals in Kake should be upheld at every stage of this work and in perpetuity. | Through use of a Memorandum of Agreement, non-disclosure agreements, and the Tribal archives, the team upholds local and Tribal authority over data collected. |
| Baseline data collection | All parties acknowledge the importance of strengthening a local database about the changing environment to support future resilience. | During the 24-month period of this study, partners completed two seasons of baseline climate data collection (project 1 in Table 4). |
| Workforce development | Importance of creating meaningful learning experiences, training, and economic opportunities for local residents and Tribal members. | More than 30 local residents worked as paid members of the research team during the study (Table 4). |
| Publication values | All parties agree to publish about this work in ways that are respectful. | The team generated zero peer-reviewed publications, but successfully planned three potential manuscripts with equitable co-authorship. |
| **Expectation** | **Meaning** | **Example during this study** |
| Data/information ownership | Data sovereignty is a key value of this work. All parties agree to negotiate agreements about data & information ownership, including memoranda of understandings, as necessary. | OVK, KTC, and the City negotiated a MOA for all data collection for the ocean monitoring project. |
| Project facilitation | Staff from each partner entity are primary facilitators for this work. | Partners maintained a core group of facilitators defined for all partners. |
| Regular updates | Regular updates will be provided by E. Figus so parties can provide feedback and recommendations to project facilitators about ongoing work. | E. Figus provided updates each month from May 2020 through October 2021. |
| Project assessment | Project assessment will take place at regular intervals. | During May 2021, representatives from each partner entity participated in an evaluation in the form of a facilitated Talking Circle. |
| Outcomes | Preserving stories/knowledge from elders in Kake; local collection of climate data; professional development experiences for locals who participate. | Two seasons ocean monitoring data archived locally; presentations at science conferences; field trips with local high school students. |
| Follow up | Results will be presented to the community. | Team members presented results at an Annual Meeting of the Tribe during 2021. |

Refer to Supplementary file B for the complete principles and expectations document.

and (1c) to identify and understand the relevance and usefulness of climate services generated through Ellam Yua co-production to Kake.

# Results

## Objective (1a) accomplishments and financial spending over 24 months

Our entire study was based around relationship building. As a process that does not end, relationship building was both a key accomplishment of this work and an ongoing process. As such, it is noted in multiple parts of this section.

## Alignment of accomplishments with mutually agreed upon principles and expectations

Project partners agreed on a shared set of Principles and Expectations (following Naquin et al., 2019; Supplementary file B) 6 months into the 24-month study. Partners agreed to uphold eight principles and six expectations for the life of the Partnership (Table 3, Supplementary file B). Much of the content in the Principles and Expectations document is typical of best practices for any research partnership following Yua et al. (2022) and similar methods (Naquin et al., 2019; e.g., "Respect & Equity"). Partners additionally included items specific to the context of Kake such as Southeast Traditional Tribal Values and workforce development (Supplementary file B).

The document stipulates that all partners have agreed to work together to benefit the community of Kake. The document also details that the Partnership and all projects within it address local needs and priorities for youth training and workforce development related to climate adaptation. However, it stops short of stipulating research project topics or outlines in detail. In line with Ellam Yua co-production, research priorities were set by the partners in Kake and were carried out within timeframes amenable to community and Tribal needs. The Principles and Expectations document functions as both a guide for Kake Climate Partnership work and a measuring stick, against which to gauge successes over time. Table 3 presents a list of accomplishments in relation to the eight principles and six expectations, and accomplishments are described in detail below.

Building a partnership centered around respect and equity was an iterative and ongoing process throughout this study. The "respect and equity" principle is closely aligned with the Ellam Yua elements for "Equity" and "Trust and Respect," which are explained in greater detail in the section titled, "Results from coding monthly logs."

The term, "sovereignty," in the Principles and Expectations was used to refer to Tribal sovereignty of OVK as well as supporting KTC and the City in exercising their local authority over decisions and information related to the Partnership. Concerns about food sovereignty and food security were the local drivers for interest in climate and environmental research in Kake.

## Field projects

During the 24-month period of this study, partners designed five field projects aimed at characterizing local impacts of climate variability and pollutants on customary and traditional foods (Table 4).

### Ocean monitoring (begun June 2020)

All three partners from Kake identified ocean monitoring as their top priority for the Partnership's first climate research project. In 2020 and 2021, a team of more than thirty local residents collected baseline climate and pollutant indicator data in seawater and shellfish tissues (including pH, salinity, conductivity, temperature, ammonia, nitrogen, fecal coliform, saxitoxin, metals, and mercury). Local partners determined project goals and outlined potential analytes of interest for data collection. E. Figus then connected with experts in the field of ocean monitoring in Alaska to advise local partners about how to design and implement the ocean monitoring program to achieve their goals. E. Figus assisted in all stages of ocean monitoring design and implementation, including: obtaining necessary permits; distributing leveraged funding; organizing training for locals on the sampling team; mentoring high school and college students on the sampling team; acting as field coordinator from her office in Juneau throughout the field seasons (assisting with supplies purchasing, creation of field log templates, sample shipments, sampling event scheduling, communications with outside labs, etc.); working with outside experts to review and summarize sampling data under non-disclosure agreements (NDAs); complying with permit reporting requirements; and prepping all project records to be stored in the OVK Archives.

### Evaluation (meeting held May 2021)

During May 2021, representatives from each organization participated in a facilitated Talking Circle (based on FNPO, 2009; OVK, 2013) to reflect and tell the story of the Partnership. Analysis of this meeting and additional evaluation activities were planned for future years.

### Research film (filmed summer 2021)

Three undergraduate interns (all Kake High School graduates) and one local videographer in Kake wrote, directed, filmed, and edited a science communication film about the Partnership, with the objective of sharing information about the Partnership with a broad audience. Film editing was ongoing at the end of the study period.

TABLE 4 Field projects in order of priority and timing.

**Kake Climate Partnership Field Projects Nov 2019-Oct 2021**

| Project | Method(s) | Amount completed | % Team time* | # Kake residents paid to work on project |
|---|---|---|---|---|
| 1. Ocean Monitoring | Western science sample and data collections | 2 seasons data collected | 50% | 30 |
| 2. Evaluation** | Facilitated Talking Circle | Meeting held in May 2021 | 5% | 4 |
| 3. Research Film | Led by local student interns | Filming complete, editing begun | 5% | 3 |
| 4. Stream Monitoring | A) Traditional Knowledge interviews B) Western science sample and data collections | Planning completed | 25% | 3 |
| 5. Climate Change Adaptation Plan for Kake | Mixed | Planning begun | 5% | 1 |

Priorities have been set by all partners using consensus during biannual meetings. *Adds to 90%, because about 10% of team time is spent on administrative, outreach, and other activities not directly related to any field project. **Project aligns with Assessment item from Principles and Expectations document (see Supplementary file B and Table 3).

## Stream monitoring (planned spring/summer 2021)

Partners planned a project to combine Traditional Knowledge with western science for monitoring water quality in local salmon streams. Salmon is an important local and traditional food to Kake residents. Methods included plans to A) train local residents to conduct interviews (Bernard, 2011) documenting Traditional Knowledge of changes in local salmon and streams over time, including observed changes in temperature, water levels and salmon runs in local creeks and streams through interviews with Elders and experts in Kake; and B) install temperature loggers and passive sampling instruments in stream locations near Kake documenting climate and pollutant indicators that may affect the ability of salmon to thrive in those streams.

## Climate change adaptation plan for Kake (planning begun in January 2021)

Partners began creating an Adaptation Plan based on the Traditional Knowledge and scientific data collected by the Kake Climate Partnership, in line with CCTHITA (2019).

The two baseline data collection projects—ocean monitoring and stream monitoring—took up most of the Partnership team's work time (Table 4) during the study. Stream monitoring was planned but not begun during the 24 months of this study. Ocean monitoring data collections were completed during both years of this study, across a total of ten sample sites in the Kake Community Use Area (Supplementary file E).

E. Figus spent up to 25% of her time mentoring local youth and students during the study. Field projects emphasized mentorship, training, and paid work opportunities for local residents and Tribal members. In addition to providing part-time work opportunities for local adults, co-authors E. Figus and B. Ki'yee Jackson supervised nine students from Kake High School, who worked as paid research assistants during the study. For more than half of these students, working on the Partnership team was their first professional job. E. Figus, B. Ki'yee Jackson, and other team members also guest lectured at the Kake High School and hosted local students on two field trips. E. Figus further mentored one undergraduate research assistant/senior thesis project (Davis, 2021) and three undergraduate student interns—all of whom received living wage compensation for their work.

Understanding that ideas of 'open data' and 'open science' do not fully align with Indigenous Peoples' rights and interests (GIDA, 2019) or the rights and interests of non-academic entities, partners have supported Tribal and local control over all data and information gathered under the Partnership. During this study, partners used a Memorandum of Agreement (MOA) and multiple NDAs as tools to formalize this local control. As an example, the local undergraduate who used ocean monitoring data in her senior thesis signed an NDA for the duration of her use of the data. Her academic adviser, mentor E. Figus, and outside reviewer signed NDAs as well.

Defining the key facilitators for this work early in the Principles and Expectations document (Supplementary file B) provided clarity for the team. Assessment was made possible through consistent creation of monthly updates and holding a formal evaluation for all partners in May of 2021. Ocean monitoring (and planned stream monitoring projects) documented critical information to support local climate adaptation and mitigation. In the 24-month period of this study, partners produced numerous reports and presentations, including for Tribal and university meetings, and regional and

national science conferences. The Partnership supported one undergraduate senior thesis project by an enrolled member of OVK Tribe (Davis, 2021), and received recognition from local, regional, and national media (Adapt Alaska and Figus, 2020; McKinstry, 2020; NOAA and Figus, 2021; Sea Grant and Figus, 2021). At the close of the 24-month period of this study, all partners agreed to continue and expand the Kake Climate Partnership and were engaged in negotiations to lengthen the existing MOA and expand the terms to include other planned projects.

## Financial spending

The Partnership was formed knowing that university partners had 24 months of funding to cover co-author E. Figus's salary and travel from two different funding sources (NOAA and USDA). University funding also covered: travel for E. Figus and partners to attend science conferences (virtually); travel for E. Figus to visit colleagues throughout Alaska; and supported some parts of field research data collection in Kake. In addition to the university funding that was available at the project outset, OVK in Kake had existing grants from the Bureau of Indian Affairs and the Environmental Protection Agency to support field project costs and local salaries/direct payments. During this study, the Partnership secured (in new funds) or leveraged (pre-existing funds listed above) over $50,000 for directly paying local residents, including the nine paid high school research assistants, one paid undergraduate research assistant, and three paid undergraduate summer interns. Sources of new funds for paying residents came from successful applications for the Partnership to host paid interns (from NOAA and Alaska Sea Grant) and for a paid undergraduate research stipend during the academic year (from the University of Alaska Fairbanks).

Field projects were designed to fit within existing funding as appropriate. Table 5 summarizes spending in the 24-month period across each of three broad categories: Travel, Salary/Direct Payments, and Field Project Costs, and provides a basic overview of spending related to this type of co-produced research, without focusing on the specifics of our budget. Partners spent over half a million dollars, not including indirect/overhead costs, to carry out co-production in Kake over 24 months.

While not able to anticipate all potential salary/direct payment costs prior to forming the Partnership, the university partner anticipated a need for funds to hire and train local research assistants or provide honoraria to local partners who volunteered time. Once the Partnership was formed, partners worked together to secure new funding to support summer internships and research stipends for local undergraduate students (through NOAA, Sea Grant, and UAF).

TABLE 5 Total approximate financial spending during the 24-month period of this study including all leveraged funds across three basic categories: Travel, Salary/Direct Payments, and Field Project Costs.

**Approximate financial spending during study**

| Expense | Amount (approximate values) |
|---|---|
| Travel | $35,000.00 |
| Salary/direct payments | $350,000.00 |
| Field project costs | $175,000.00 |
| **Total** | **$560,000.00** |

The category "Travel" includes travel of co-author Figus, as other travel was canceled during the 24-month period of the study, due to the COVID-19 pandemic. The category "Salary/Direct Payments" refers to costs of Figus's salary, partner staff time, and payments to residents in Kake for work related to the Kake Climate Partnership. The category "Field Project Costs" includes costs of supplies, shipping, sample processing, and any direct payments to people not residents of Kake who assisted with Kake Climate Partnership work during the 24-month period. All values refer to funds used, and do not include indirect/overhead costs.

## Results from coding monthly logs

All the text in each of the monthly log files was coded with at least one of the deductive or inductive codes. In some cases, multiple codes were assigned to the same portion of text. One additional code—"Flex-Pivot"—was created inductively during the coding process, yielding a total of 23 codes (Table 6).

### Objective (1b) how the ellam yua co-production elements manifested in our work

In the review of E. Figus' logs, the most prominent elements from the Ellam Yua framework (Figure 1) were "Relationships", "Capacity", "Means & Ability", and "Communications" (Table 6). Elements "Deliberate & Intentional", "Empowerment", and "Gather Information" also had high incidence in the text analysis. Five of the seven most referenced Ellam Yua elements in written logs were from the "Conceptual Tools" of the Ellam Yua framework, with two elements from the "Action Circle"—"Communications" and "Gather Information." We also report results from analysis of the "Challenge" code here as it had the second highest incidence overall.

Other elements—including "Trust & Respect", "Decolonization", and "Practice Reciprocity"—had a lower incidence of occurrence in E. Figus' log notes. "Knowledge Systems" and "Equity" had the fifth and seventh lowest incidence in coding from the logs overall. The Ellam Yua elements with lowest incidence in the review of logs were "Ethical", "Problem Definition", "Identify Question", and "Sovereignty".

The highest incidence codes were encountered >10 times more often in the monthly logs than the lowest incidence codes.

TABLE 6 Type of code (Deductive or Inductive); Code Name (either an element from the Ellam Yua co-production framework or an inductive code); which part of the Ellam Yua co-production framework each code belongs to (see Figure 1; not applicable for the 'Challenge' and 'Flex-Pivot' codes); and # References (absolute incidence) of each code used in our analysis.

| Type | Code name | Part of Ellam Yua Co-Production Framework | # References |
|---|---|---|---|
| **Codes used in text analysis of monthly logs** | | | |
| Deductive | Equity | Outer Ring | 27 |
| Deductive | Trust and Respect | Conceptual Tools | 66 |
| Deductive | Relationships | Conceptual Tools | 281 |
| Deductive | Empowerment | Conceptual Tools | 148 |
| Deductive | Means and Ability | Conceptual Tools | 213 |
| Deductive | Capacity | Conceptual Tools | 234 |
| Deductive | Deliberate and Intentional | Conceptual Tools | 165 |
| Deductive | Ethical | Conceptual Tools | 15 |
| Deductive | Decolonization | Conceptual Tools | 45 |
| Deductive | Sovereignty | Conceptual Tools | 22 |
| Deductive | Problem Definition | Action Circle | 16 |
| Deductive | Identify Question | Action Circle | 17 |
| Deductive | Develop Methods | Action Circle | 64 |
| Deductive | Gather Information | Action Circle | 123 |
| Deductive | Information Analysis | Action Circle | 26 |
| Deductive | Communications | Action Circle | 201 |
| Deductive | Review Results | Action Circle | 34 |
| Deductive | Control of Information | Action Circle | 53 |
| Deductive | Practice Reciprocity | Action Circle | 40 |
| Deductive | Knowledge Systems | Converging Through the Process | 23 |
| Deductive | Co-Production of Knowledge | Goal | 70 |
| Deductive | Challenge | N/A | 249 |
| Inductive | Flex-Pivot | N/A | 17* |

*Absolute incidence of this code is not meaningful, as it was inductively added partway through the coding process, without returning to re-coding earlier texts.

Figure 4 shows a visual representation of this relative incidence across all deductive codes.

Elements of "Sovereignty", "Ethical", "Problem Definition", and "Identify Question" had low incidence of coding from log notes but were nevertheless prominent in the 24-month study period, as evidenced in the jointly agreed upon Principles and Expectations document (Supplementary file B) and research processes.

We ran queries for Pearson's and Jaccard's correlation coefficients across the 22 deductive codes, to seek meaningful clusters of codes and to attempt to capture codes that were prominent in the Principles and Expectations but did not have high incidence in the coding. Results from a query using Pearson's correlation coefficient across the 22 deductive codes did not yield any obviously meaningful groupings of codes. Results from a query using Jaccard's correlation coefficient across the 22 deductive codes in the E. Figus logs showed how the elements were clustered in *project activities* during the study (Figure 5).

The six Jaccard's correlation clusters displayed how the 21 Ellam Yua elements and the deductive code for 'Challenge' were correlated in the monthly logs. We found the six clusters represented five meaningful groups in the context of the Kake Climate Partnership project activities during this study: Action Circle Basics; Human Interactions; Field Projects; Partnership Operations; and Big Ideas.

## Action circle basics

This group includes two clusters of basic research steps from the "Action Circle" that had low incidence in coding. The first cluster includes the codes 'Identify Question' and "Problem Definition" in a single cluster. These codes had low incidence in the logs but were successfully achieved during the study. Partners in Kake had clearly defined problems and research questions from the beginning of our partnership, thus, the team did not spend a lot of time on these Ellam Yua elements, beyond achieving consensus about prioritizing an order of project completion (see Supplementary file C). In contrast, the


FIGURE 4
Word cloud displaying relative incidence of the 22 deductive codes used in our analysis, with the higher incidence codes displaying larger and lower incidence codes displaying smaller, with size dependent on absolute incidence of each code. Colors do not display any categorical difference between codes and were chosen to match colors in Figure 7. Created by M. Rhodes-Reese in Adobe Illustrator, using NVivo software output.

second cluster including "Information Analysis" and "Review Results" had low incidence in the logs because these elements were not completed in the 24-month period.

### Human interactions

This group includes codes "Trust & Respect", "Deliberate & Intentional", "Communications", and "Relationships." "Relationships" had the highest coding incidence in the E. Figus logs. The other three codes in this cluster were not in the top four for incidence but were correlated with 'Relationships,' as they were a key part of relationship-building. Partners communicated regularly *via* emails, phone and video calls, and face-to-face meetings, and E. Figus traveled to Kake nine times during the study period (see section titled, "Building a partnership through written and agreed upon principles and expectations").

### Field projects

This group includes five high incidence codes: "Gather Information", "Empowerment", "Means & Ability", "Capacity", and "Challenge." This group demonstrates how the field projects were more than simply data collection. Field data collection was the cornerstone of "Empowerment" in the form of employing and mentoring local undergraduate and high school students. Partners also had to secure and maintain necessary "Capacity," in the form of local people available/able to do the work, and "Means & Ability," in the form of funding and supplies for the work. The code for "Challenge" was strongly correlated with elements in this field project theme.

### Partnership operations

This group includes three low incidence codes from the "Action Circle:" "Practice Reciprocity", "Control of Information", and "Develop Methods." These three codes formed a key part of day-to-day operations for the Kake Climate Partnership during the study. For example, how partners chose to "Develop Methods" was related to how information gathered during field projects was stored and shared (i.e., "Control of Information"). As with two of the codes in the "Action Circle Basics" group, these elements were coded with low incidence, not because they were unimportant, but rather because they were fully established during the first few months of the Partnership. Processes of meetings and decision-making involved "Practice Reciprocity"—often in the form of sharing stories and sharing food—and all these actions were guided by broader concepts in the "Big Ideas" group (see below).

### Big ideas

A final group for six big ideas from the Ellam Yua framework includes: the "Outer Ring" code for "Equity"; "Conceptual Tools" codes "Ethical", "Decolonization", and "Sovereignty"; the code for converging "Knowledge Systems"; and the goal of achieving "Co-Production of Knowledge." These "Big Ideas" codes had lower incidence as they were not closely related to the day-to-day operations of the Partnership, which constituted the core content of the written logs.

## Objective (1c) challenges faced during the 24-month period of study

The "Challenge" code had the second highest incidence of any code in our analysis. We identified five themes in the "Challenge" code: Logistics, Priorities, Communication, Capacity, and a Global Pandemic.

### Logistics

Logistics (coordinating people, supplies, funding, projects, etc.) are a challenge in any type of research. In the geographic context of Alaska, and the context of Kake as a rural community not connected to other communities by road, it is common for projects to have unexpected delays due to weather or shipments of supplies. We anticipated added costs for all aspects of our field projects and in-person meetings, as compared with projects in the contiguous United States. Other challenges during the study included: balancing logistics across four different partners with team members in multiple communities across Alaska; leveraging, securing, and administering multiple sources of funding; achieving multiple goals on a limited timeline; and maintaining the focus needed to pay careful attention to the Ellam Yua co-production elements at every stage of our work.

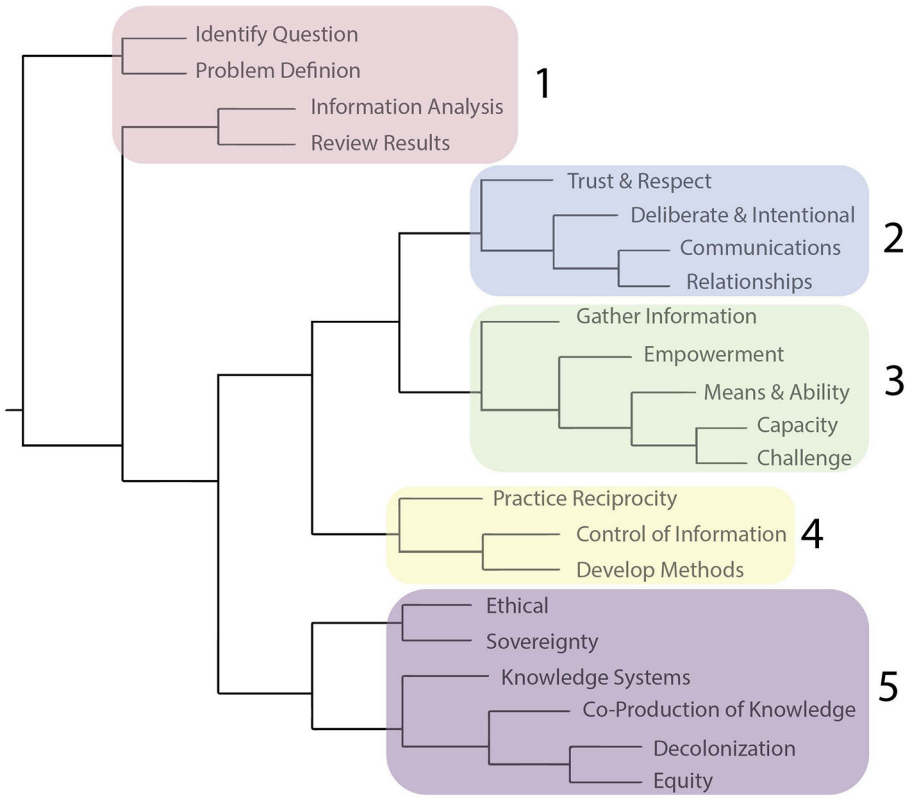


FIGURE 5
Six clusters of codes based on similarity of words coded among them. The six clusters represent five meaningful groupings in the context of the Kake Climate Partnership project activities during this study. The clusters are displayed as branches in the above tree diagram, while the five meaningful themes are displayed using rounded transparent boxes, numbered 1-5. Each number corresponds to a meaningful group as follows: 1. Action Circle Basics; 2. Human Interactions; 3. Field Projects; 4. Partnership Operations; and 5. Big Ideas. Colors are used to differentiate clusters. Created by M. Rhodes-Reese in Adobe Illustrator, using NVivo software output.

### Priorities

Juggling the priorities of multiple partners and multiple projects was a challenge throughout this study. Partners had diverse goals for how to prioritize their time and efforts. For example, ACCAP had priorities related to attending conferences and compiling peer-reviewed papers, while OVK, KTC, and the City shared priorities related to balancing research schedules with the schedules of Tribal and community events and customary and traditional food harvests. The team also experienced occasions of needing to shift priorities—often in the form of slowing down field projects—to uphold elements of "Trust & Respect", "Empowerment", "Decolonization", "Practice Reciprocity", and "Sovereignty".

### Communication

Some partners preferred to communicate *via* email, others *via* phone, and some preferred face-to-face meetings. Some partners worked on typical weekday 9am−5pm schedules, but most did not. Additionally, the community of Kake had limited bandwidth capabilities for Wi-Fi and intermittent blackouts of cellular service during this study—as is typical of many rural communities in Alaska.

### Capacity

The Partnership experienced *capacity limitations* and *capacity imbalance* throughout the study. The primary capacity limitation was that only one team member had full-time work dedicated to the Partnership.

> *In my role as…the one person who is full-time committed to the Partnership, I must find balance across the three types of interests: my boss (or the larger entity I represent in academia), myself, and my partners. This is not an easy task, and it is one that feels like burnout at times. Because there is always something more that needs to be done for one of the 3 spheres.*–E. Figus log notes June 2021

The primary capacity imbalances were (a) this was a university-initiated partnership with full-time capacity coming solely from the university partner; and (b) the university and Tribal partners

were the most active in terms of time and funding dedicated to the Partnership during the study period, with the City and KTC dedicating less capacity.

> *I feel like a lot of this work is turning into ACCAP and OVK, with a side of everything else. I hope that is not a weakness that will turn into a fissure for the Partnership…*–E. Figus log notes April 2021

#### Global pandemic

The COVID-19 pandemic interacted with the four other "Challenge" code themes through rapid and unexpected changes to our research goals, project design(s), timelines, travel, and funding structures. The pandemic exacerbated typical logistical challenges, caused a shift in our project priorities, improved our remote communications, and had mixed impacts on our capacity.

### Flexibility in responding to challenges

The "Flex-Pivot" code emerged inductively during the coding process of E. Figus' logs. 'Flex-Pivot' is not part of the Ellam Yua framework and was added partway through the coding process to highlight a need for flexibility/to pivot that was central to the study. As it was added partway through the coding process, 'Flex-Pivot' is not fully represented in the final set of codes and the absolute incidence ($n = 17$) of this code listed in Table 6 is not meaningful.

The "Flex-Pivot" code content includes ways partners pivoted in response to challenges that occurred during the study. While not an exhaustive list of responses to challenges, the 'Flex-Pivot' code sheds light on both the need for flexibility in any co-production process, as well as ways that E. Figus and other partners chose to pivot in response to various challenges. We identified five themes in the 'Flex-Pivot' code, each of which represents an applied example or a set of examples from the first 24 months of the Partnership (Table 7).

#### Use of language

In Kake, this work was defined as a 'partnership' because terms like 'co-production' and 'actionable science' did not have clear meanings in the non-academic spaces of Tribal and community partners.

#### Rethink the role of scientific research and researchers

Typical academic research may include 5–10% outreach or engagement of some kind. The Partnership work done during this study was at minimum 50% Tribal and community engagement, youth mentorship, and administrative support for Tribal and community partners.

#### Flexibility in communication styles

Some partner entities wanted to be in constant communication, while others preferred to communicate only when there were specific decisions to be made. Over the study period, E. Figus provided monthly presentations to one partner entity, while the other three partners chose to receive written updates via email each month. Tailoring communications to fit individual needs took extra time in the beginning of the Partnership but saved time and effort once a rhythm was established.

#### Flexibility in process with dedication to core principles

In the face of unexpected events, short- and medium-term goals must shift. Major events, like a global pandemic, or minor events, like a mechanical breakdown of a sampling boat, can impact project timing and funding. Partners made alterations to almost every aspect of their work over the course of the 24-month study period, including changes to: funding sources; the order in which partners carried out projects; who were lead contacts from some partner entities; the way(s) each partner chose to participate and communicate with larger group; and the way(s) partners were able to meet with one another. However, partners *did not change* the core principles and expectations from the written and agreed upon document created in May of 2020 (Supplementary file B). Knowing when to be willing to flex and pivot was just as important as understanding when to stick to core long-term goals. In this study, having a document that clearly stipulated a shared long-term vision and day-to-day expectations meant no partner had to guess about whether a near-term activity was aligned with long-term goals.

#### Transparency in acknowledging successes and challenges

The Kake Climate Partnership enjoyed many successes in the 24 months of this study. Partners were also transparent with one another from the beginning about challenges. Through open discussions, partners were able to identify and respond to the key challenges presented in this paper.

## Discussion

In this study, we found that creating the Declaration of Principles and Expectations (as recommended in Naquin et al., 2019; Supplementary file B) was key for success. By intentionally situating the Traditional Tribal Values (CCTHITA, 2022) in the Principles and Expectations, partners were able to use the document as an implicit and explicit tool for decolonization throughout their work. We also found that carrying out regular check-ins between individual partners and as a group was key to ensuring expectations were met over time in a transparent fashion. It was important for partners from outside the community to measure the time spent in Kake in weeks or months, not days, each year. This work was also expensive, and some costs were not possible to anticipate. While some costs of this work were known at the beginning, such as

TABLE 7 Example quotes from the monthly logs across the five themes that emerged from the 'Flex-Pivot' inductive code.

**Examples of the 'Flex-Pivot' code across five themes**

| 'Flex-Pivot' theme | Example Quote(s) from monthly logs |
|---|---|
| 1 | *. . . the jargon creates a smokescreen that does not always make sense in communities [Research Colleague pers. comms, 2020]. In the context of Kake, we have defined ourselves as a 'Climate Partnership' and more generally as a 'Research Partnership' rooted in climate and environmental projects*—September 2020 |
| 2 | *. . . I think I [typically] unconsciously focus 75% [of my time] on scientific research, including [Indigenous Knowledge] as part of scientific research, with about 25% community engagement. I have not thought about this fully yet. How much of my current [co-production] work should be scientific research*—September 2020<br>*[Knowledge Bearer from Kake] recommend[ed] that I let my voice be quiet while doing the work to support the capacity of my research partners, my Indigenous partners, to lead our projects in a way that satisfies their goals. So, I can run around and get project materials and help design methods for water sampling, but I need to step aside and back when it comes to leadership and big decisions, as well as how we present our work to the outside*—September 2020 |
| 3 | *It feels like a huge weight has been lifted. I felt uncomfortable with worry for a week, but I am glad I simply thanked the [partner] for their time and got off their call. They are happy with the Partnership (or at least not disappointed) and just [did not] want me [presenting at] their monthly meetings*—January 2021 |
| 4 | *Every few days, I have drafted a new potential sampling schedule, just in case things are ready to go. But no sampling took place. . . due to [boat] mechanical and COVID issues. . . COVID is spreading in Kake. We had a plan to get calibrations completed and potentially two sampling events completed, but one of our lead samplers is hunkering down due to a positive case of COVID in the family, and the case count in Kake continues to rise. Another 'hurry up and wait' week for ocean monitoring, while we deal with the stress and worry of everyone's safety*—August 2020<br>*The [Declaration of Principles and Expectations] has become part of everything that we do, and it is the strongest glue holding us all together throughout this pandemic. The [Declaration of Principles and Expectations] is a work product, a deliverable in itself because it reciprocally defines us as we define it. . . The [Declaration of Principles and Expectations] is meant to be our application of the [co-production] model [from Ellam Yua et al. (2022)]. The [Declaration of Principles and Expectations] ensures that we are all at the Kake Climate Partnership 'table' for the same reasons. We all understand that this partnership is much bigger and more meaningful than any of the individual pieces or people involved. We agree explicitly to uphold the principles of the [Declaration of Principles and Expectations] in all that we do*—November 2020 |
| 5 | *I [am] struck by how quickly 12 months has gone by. . . We have had great success, but also great challenges and potentially upcoming failure...I am losing faith in the idea that meaningful [co-production], partnership work can be conducted in a 24-month window. Certainly, it could not be done in 12 months*—October 2020<br>*During the last week of February, I was informed by [university funding staff] that paying for Covid testing prior to and during travel to Kake will not be an 'allowable expense' on the [Federal] grant [we are using to cover my travel]. My travel plan was not reviewed by anyone other than [my supervisor], to my knowledge. This trip planning is very different from the trip in October. I made an appointment at [the regional Tribal health consortium] in Juneau for a pre-departure test and prepaid the $145 charges. I wonder if there is a more flexible fund that we can pull money from to pay this cost*—February 2021<br>*There are many different balls in the air that require my attention at the moment. . . This is the month where [co-production] turns into [a] choice of who gets the money from the emptying pot*—January 2021<br>*A nice outcome of this month (and the trip to Kake) was that I walked away with confidence that our partners want to carry on past November 2021, so we have a bit more time to complete our goals together*—March 2021<br>*OVK and everyone in Kake have adeptly and gracefully molded the [Kake Climate Partnership] into their other ongoing initiatives. In this way, I am confident that [Kake Climate Partnership] has constructively contributed to long-term projects and planning in Kake in a positive way. But I do hope we can find a way to make this a more lasting program*—October 2021 |

The numbers 1-5 in the table correspond to five types of 'Flex-Pivot' themes as follows: 1. Use of language; 2. Rethink the role of scientific research and researchers; 3. Flexibility in communication styles; 4. Flexibility in process with dedication to core principles; and 5. Transparency in acknowledging successes and challenges.

travel for in-person meetings, many other costs could not be foreseen, for example, costs of projects or field research that were only developed after the Partnership was formed. Funding uncertainties were exacerbated in our study by the COVID-19 pandemic. Flexibility was key for all partners—for everything from defining research objectives to managing time. Our inductive 'Flex-Pivot' code demonstrates the importance of adaptability in implementing Ellam Yua co-production. We also found that this type of co-production work takes much more than 24 months of time. While individual projects can be designed, implemented, and completed over shorter timescales (e.g., a few months), the process of building any meaningful

partnership takes years, and may be expected by a community to last much longer.

The Kake Climate Partnership used many of the elements of co-production during this study, but did not employ a 'wholly' co-productive approach as described in Yua et al. (2022):

> *The use of some of the conceptual tools of co-production should not be—though increasingly is—confused with employing a wholly co-productive approach. That is not to say that we discourage the use of a subset of the conceptual tools presented here, but rather that a true CPK [co-production of knowledge] approach requires equity through the entire research process, from the very beginning. Additionally, it is far more important to do co-production than it is to talk about it or label things as it* (p. 27).

We found that in the 24-month period of this study, it was not feasible to fulfill the elements of 'Review Results' or 'Information Analysis' in a meaningful way. Similarly, many elements were less prominent than they might be over a longer time period. 'Decolonization' was a shared goal among partners but was not commonly identified in coding. Kake Climate Partnership field projects included both Western science (e.g., ocean monitoring) and Indigenous Knowledge (e.g., Talking Circle Evaluation), but during the 24 months of the study, partners did not achieve the bringing together of two different 'Knowledge Systems' as described by Yua et al. (2022) (Table 8) in a concrete way.

Partners engaged in actions for the elements 'Trust & Respect' and 'Practice Reciprocity', but in just 24 months of time and starting from scratch (no prior relationship between ACCAP and the other partners), partners did not completely fulfill these elements (Table 8). Partners seeded strong roots for the less prominent elements to be fulfilled in the future, but these less prominent elements would likely require more than 24 months of time to fulfill in any co-production partnership.

## Geographical context of Kake

Delivering salient climate services hinges on understanding and responding to specific characteristics of user needs, including local knowledge and geographic context (McNie, 2013; Clifford et al., 2020). The Partnership research priorities were community-driven and field research was grounded in the landscape, geography, and Tribal context of the Kake Community Use Area. While Ellam Yua co-production may be applied in many different regions, there may be features of the Partnership that are unique to its geographic context.

The work presented in this paper is based around four entities cooperating to come up with a group plan to best study climate change impacts and plan for adaptation throughout the Kake Community Use Area (Figure 2). The food sovereignty and food security project priorities in Kake may or may not align with those of other regions, and financial spending in Kake may not align with costs in other regions. Kake is also a community where the leadership entities have a strong track record of working together for the betterment of their community (See text footnote 1). Not every Alaska Native community has cooperation between the municipal government, Tribal corporation, and Federally recognized Tribe. In communities that lack this level of coordination, the complex, tripartite, colonial-imposed system of governance in Alaska Native communities (Carlo, 2020) can create obstacles to climate adaptation.

We found that the Ellam Yua co-production framework developed for use in the Arctic was applicable in Kake, even though Kake is not located in the Arctic. We expect Ellam Yua co-production could be useful for other research partnerships among Indigenous and non-Indigenous entities, regardless of geographic context. Similarly, some characteristics of Kake's geographic context may be relevant in other settings. For example, non-Indigenous academic researchers seeking to partner with Indigenous Tribes and/or rural or remote communities in other regions may find some key parallels in our descriptions of travel, time, funding, and capacity needs for their work.

## Reflections about challenges during this study

### COVID-19

Challenges related to the COVID-19 pandemic heavily impacted this study by influencing *how* co-production activities were able to take place. Interestingly, however, while the pandemic created some challenges for day-to-day work—especially due to limitations on in-person gatherings—the Partnership was especially well-positioned to continue functioning throughout the pandemic with limited risk. For example, the COVID-19 pandemic unexpectedly improved our team's remote communications abilities, through increased affordability of Wi-Fi, cellular service, and increased access to laptops and computers purchased through Federal relief funding. The pandemic also normalized the use of and access to online video conferencing software[2] like Zoom, which made it easier for our team to communicate with one another remotely. This allowed our locally led ocean monitoring work to proceed with limited interruptions. Writing about COVID-19, Marino et al. (2020) ask researchers to, "pause and reflect on the ethics of research in times of acute risk exposure." Marino et al. (2020) also correctly urge researchers to question whether their work is "beneficial, collaborative, or necessary." By using Ellam Yua co-production methods—including centering local priorities,

2 E. Figus and B. Ki'yee Jackson personal observations, 2021.

TABLE 8 Example quotes from monthly logs of elements from the Yua et al. (2022) framework that were not fully achieved (fulfilled) during this study.

**Limitations to fulfilling Ellam Yua co-production elements**

| Type of limitation | Example quote from monthly logs |
|---|---|
| 'Trust and respect' element | *[The] biggest hurdle is trust; I like the term 'moving at the speed of trust' because that is what I do… it is a reality for myself and the Indigenous people of Alaska and probably around the world; we cannot go into things trusting because it has just been proven, years of oppression of our people by a system that was created not for people of color; it was created for the people of European descent; nothing that is on the books, whether it is policy, law, whatever; that wasn't written for people of color. We came as an afterthought… there is always something else behind what is being asked us. I don't know how to explain that, but there is always an underlying issue… I am leery of people that want to come and help our community. Not that I'm not appreciative of their efforts; it is that we have to keep our guard up; always, as Indigenous people… I think mainly it comes down to trust. It is sad that that's always there for me, but I'm not going to go into something without mentioning that. And I won't ever hide that from anybody. Trust is earned, and it won't come easy*--OVK President Joel Jackson (excerpt from log notes, October 2020) |
| 'Practice reciprocity' element | *What is in it for them? This is the key to the whole [co-production of knowledge] process. What purpose does it serve an over-extended tribe and small community to get lip service and paperwork from the university? Without financial and temporal investment, the Partnership is meaningless. When I proposed designing climate research with the aim of providing tangible benefits to Kake, our partners at the tribe and city and corporation all said emphatically that workforce development HAD to be part of what we did. And field work ideas came pouring out of the tribal staff and leadership. The implication from early on was that I needed to find or bring money to the table to support those endeavors. Otherwise, what am I doing here in this 'partnership' space*—January 2021 |

training, and mentoring local residents to carry out fieldwork, and supporting the outside researcher E. Figus in coordinating fieldwork activities from her home office—the Partnership was able to thrive despite the pandemic.

## Other challenges

We found that challenges related to 'Logistics,' 'Priorities,' and 'Communication' were inevitable and likely would be ubiquitous across any similar partnership, while challenges related to 'Capacity' were contextual.

Capacity imbalance has the potential to be a positive aspect of co-production, for example when an entity with ample funding assists an entity with less funding capacity. However, when a capacity imbalance is sustained throughout a co-production partnership it has the potential to perpetuate inequitable power differentials that impede local and tribal sovereignty in the research.

During this study, the Partnership leaned heavily on the efforts of a few members (including co-authors E. Figus and B. Ki'yee Jackson) and workload was not balanced across all four partner entities. Challenges with 'Capacity' were strongly influenced by a *constricted timeline* and *directional formation* (as interpreted from the monthly logs and reflective conversations among co-authors).

Constricted Timeline: This paper reports experiences in the first 24 months of the Kake Climate Partnership. While the Ellam Yua model is nonlinear, field projects had strict linear timelines, and the Partnership depended on full-time work capacity from co-author E. Figus. E. Figus' position as a postdoctoral researcher (and coordinator/facilitator of the Partnership) was limited to a 36-month period, after which the future of the Partnership was unclear.

Directional Formation: ACCAP initiated the Partnership with the goal of attempting to carry out co-production within a 24-month timeframe. In this approach, the work in this study deviates from the Ellam Yua framework, which recommends that Indigenous partners play a role in initiating partnerships for their benefit. Some challenges faced by the Partnership, including concerns about balanced input and participation from all partners, stem from this one-sided approach to forming a partnership (David-Chavez and Gavin, 2018).

The 'Capacity' challenges of a constricted timeline and directional formation were specific to this project and could be eliminated from future work through careful and deliberate planning. If the project had been planned on a longer timeline from the beginning (5 or more years), both types of capacity issues could have been resolved. With a longer timeline for work, it is likely that: (a) the Partnership would have been able to fulfill all the Ellam Yua elements to achieve a wholly co-productive approach (see beginning of section titled, "Discussion"); (b) there would have been less of a focus on linear scheduling during the first two years; and (c) there could have been more time devoted to planning, with the opportunity to deliberately structure balanced input and participation from all partners.

## A note about potential limitations of this study

While the Partnership provided tangible benefits to the community of Kake, the constricted timeline of 24 months and directional formation (described above) limited the ability of partners to employ a wholly co-productive approach to this work.

The written logbook notes and monthly update documents were analyzed by the same individual who authored them; however, results of the analysis were discussed by the author team in our reflective conversations. While only two of our four research partner entities were participants in the reflective discussions and are co-authors on this paper, drafts and the final version were reviewed and approved by all partner entities prior to publication. More formal evaluation of the Partnership that engages all project partners was ongoing at the time of this writing and will be reported elsewhere.

## Key features that made Kake Climate Partnership climate services relevant and useful for tribal and community partners

The field of climate services is broadly aimed at producing climate data, information, products, or knowledge that is/are usable in decision-making, planning, or policy (Brasseur and Gallardo, 2016; Daly and Dilling, 2019). Co-production has been put forward as a process that yields a greater likelihood of usefulness and usability in climate services (Lemos and Morehouse, 2005; Dilling and Lemos, 2011; McNie, 2013; Kruk et al., 2017). In the Kake Climate Partnership, several features have been significant in creating climate services and products that are relevant and useful for the Tribe and community partners.

### Workforce development

One of the most important priorities for local members of the Partnership during this study was building local climate capacity through workforce development. Indigenous communities and Tribes around the United States face barriers to successful workforce development, including: low self-confidence; a lack of professional role models; a paucity of 'living wage' job opportunities; or little room for professional advancement (NCAI, 2020b). All these barriers commonly lead to a 'brain drain' dynamic, where young people leave Indigenous communities to look for jobs elsewhere (NCAI, 2020a,b). There is a critical need to build capacity in the form of appropriate education, training, and job opportunities necessary for locals to take the lead in climate change research, adaptation planning, and mitigation.

We acknowledge barriers to workforce development faced by Indigenous communities around the United States (NCAI, 2020b), while recognizing the local talents and capabilities of people in Kake. In Kake, it is challenging to grow local research and management programs because there is a lack of people to fill jobs (See text footnote 1). But it is critical to create job openings to provide for local college graduates upon completion of their degree programs. While it is common for a university to harness scientific expertise in a research partnership, it is less common for university partners to seek guidance from Indigenous experts, to trust and follow community and Tribal lead, and center research efforts around local workforce development. Providing local workforce development opportunities in rural Alaska is especially relevant for the young people (NCAI, 2020a) who will comprise the next generation of climate change adaptation leaders.

### One element in the larger local vision

We found that *when the climate services process is centered on Tribal and community priorities and locally identified science needs, the climate science aspect becomes just one element in the implementation of a larger local vision and goals*. In contrast to climate service models that provide downscaled scenarios to end-users for use in planning, the Partnership started with local needs and priorities. Projects were aimed at increasing adaptive capacity to climate change in Kake, based on local priorities of food security/sovereignty and data sovereignty. With an emphasis on process, Ellam Yua co-production goes beyond the provision of climate information by generating procedural benefits for local partners such as local empowerment. Our case study in Kake supports findings from Dilling et al. (2019), that the most critical adaptation-related needs may not directly relate to climate and instead relate to empowering communities in the face of climate change. The Partnership did not attempt to carry out climate services co-production as described in Baztan et al. (2020). However, we similarly found that process-related benefits of co-production have the potential to generate local capacity that may be mobilized to face climate change. Through providing workforce development opportunities in Kake, bounded research projects contributed to strengthening long-term local capacity for climate adaptation.

During this study, the Partnership provided climate services and information through field project scoping, design, implementation, and archiving of data for use by local leaders and future generations in Kake. The Partnership provided tangible benefits for individual residents of Kake in the form of compensating local members of our field teams and mentoring youth in every project. Tangible benefits for the Tribe and community of Kake were realized by meeting local information needs and conducting climate research to directly support local adaptation planning, through building two local climate monitoring programs (ocean and stream monitoring) and

focusing on archiving the resulting data locally in Kake for future use.

The two climate monitoring projects addressed high priority food resource issues that were identified on both local and regional levels. For example, the regional Central Council of the Tlingit and Haida Tribes of Alaska Climate Change Adaptation Plan (CCTHITA, 2019) lists salmon as a species in the category of "very high priority" area of concern, due to, "cultural, social, and economic value and the limited tribal control over their adaptive capacity" (p. 25). The ocean monitoring project in Kake collected information necessary to carry out the 'Resilience Strategies' for salmon stocks, listed on p. 28 of the Adaptation Plan. Local partners led the ocean monitoring field project during 2020 and 2021, while outside experts (including E. Figus) provided additional capacity as needed to achieve a program that produced data that was relevant, salient, and useful for the Tribe and community in Kake.

Collection and storage of ocean monitoring data in Kake laid the groundwork for local leaders to carry out successful adaptation planning in the face of continued climate change, specifically about the management of customary and traditional food resources. During this study, OVK, KTC, and the City used the data generated to educate the community about climate impacts on customary and traditional foods (Davis, 2021). In the future, local partners plan to use data and information from ocean and stream monitoring to compare with regional data to inform decisions including whether and how to: expand stream and coastal restoration projects near Kake; introduce legislation limiting what ships are allowed to discard or discharge into State and Federal waters around Kake; alter storage practices at the local dump; and shift the time and location of customary and traditional food harvests.


FIGURE 6
A mixture of traditional Tlingit formline drawing techniques and European line drawing techniques to display connections in the Kake Climate Partnership. Two hands are pictured in the figure, holding up a rendition of a pristine natural environment pictured inside a circle (mountains, forests, water, sun). One hand represents Traditional Knowledge and the other represents Western science. Both hands share a vision of a pristine environment with clean water and healthy forests. The two hands are coming together with a common goal to protect and maintain that pristine natural environment through understanding climate change and adapting to it. Each hand is reaching out to the pristine environment, emphasizing that partners are all connected and have a common goal of preserving the natural environment as best we can. The phrase underneath the hands, 'We are all connected', communicates a shared vision among partners that everything is connected—partners have a shared vision of unity and common goals for the future. The phrase, 'Kake Climate Partnership', forms the top of the drawing, symbolizing how it is made possible through the two hands of Traditional Knowledge and Western science working together. Artist credit: B. Ki'yee Jackson; digitized by Lori Styczynski at Roy's Embroidery, in Juneau, Alaska.

## Transformative climate and environmental science

The field of climate services is increasingly focused on holistic, integrated, and 'next generation' approaches (Jacobs and Street, 2020; Irumva et al., 2021; Tudose et al., 2021), including transdisciplinary co-production (Steynor et al., 2020). Vogel and Bullock (2021) note that Indigenous worldviews that "promote holistic problem-solving through social capital, collaboration and capacity-building" lend themselves well to climate change adaptation. In the Kake Climate Partnership, we found that *co-production can be used to explicitly define a collective vision among partners that is a transformative way of doing applied climate and environmental science.* Partnership members have a shared vision to deliberately shift away from colonialism in research and resource management (Tuhiwai Smith, 2012), and toward Tribal and local control over research and management of resources. In line with Dilling and Lemos (2021), we found that successful research co-production for climate services requires a commitment on the part of outside researchers to understand what Tribal and community members view as equitable and desirable outcomes. Creating a shared vision makes it possible to avoid harming communities (Dilling et al., 2019) and conduct climate research that provides tangible benefits for Tribal and community partners. This was especially relevant, as our study took place during the COVID-19 pandemic. Funding to accomplish the community designed and led research during this study was leveraged from a range of sources and multiple partners contributed funds approximately equally (OVK and ACCAP).

The Partnership was formed as a deliberate attempt to implement Ellam Yua co-production. Partners worked as a team to define challenges, identify strategies, collect data, and use findings from climate change research in support of adaptation planning. As such, all partners were both consumers and producers of climate information. Figure 6 shows a visual depiction of Partnership Principles and Expectations and connection among partners. Created

by co-author Ki'yee Jackson, this image underscores the significance of holistic approaches to climate adaptation. Including artistic and culturally relevant elements in addition to scientific elements in the delivery of climate services constructs more enduring adaptive actions to climate change than are otherwise possible (Benson et al., 2020).

### Boundary spanning

To use climate services to support truly transformational adaptation Boon et al. (2021) argue that climate service providers need to widen their scope and skills. In this study, *the role of the university researcher shifted from focusing on personal research interests to focusing on supporting local needs and priorities.* Respecting and engaging with Indigenous methodologies necessitates focusing climate services work on process, relationality, and service to community (Wilson, 2008). Postdoctoral researcher E. Figus from a NOAA RISA program acted as a boundary spanner (Bednarek et al., 2018; Posner and Cvitanovic, 2019) to connect community and Tribal leaders with capacity and support to achieve their climate research and adaptation goals. The Partnership team emphasized Tribal and community driven priorities and decentered the academic university perspective. ACCAP's role was primarily to provide training and mentorship, while respecting the sovereignty, intellectual property rights, and values of Tribal and community partners. Partners in Kake had a shared interest in collecting the scientific data that they needed to manage the Kake Community Use Area and the university partner mentored local partners in going after that scientific data.

## Kake Climate Partnership supports a co-production learning network

Throughout the United States, NOAA RISA programs like ACCAP have been designed as human learning networks, prioritizing wide participation in learning to support transformational climate services (Combest-Friedman et al., 2019). In learning networks, the development and application of knowledge is multifaceted and individual team members must play multiple roles in the climate services process (Kettle et al., 2017). As boundary spanning organizations, the RISA programs can serve multiple roles to link science and decision-making in support of regional learning networks (Kettle and Trainor, 2015).

The Kake Climate Partnership was made possible in part because of the existing local initiatives for a Tribal Conservation District and a Guardian Watchmen Network, and by an existing regional learning network—the Sustainable Southeast Partnership. In turn, the work of the Partnership during this study was able to seed potential *future* learning networks, by creating trust relationships and collecting data necessary to support the Guardian Watchmen and Tribal Conservation District initiatives. The first 24 months of the Partnership was a seed for all three programs—the Kake Climate Partnership, Guardian Watchmen, and a Tribal Conservation District—to work together in unison, as 'one hand helping the other' (Figure 6). For example, developing the ocean monitoring program provided the Tribal and community leadership in Kake with some of the experience and capacity necessary to embark on a Guardian Watchmen program in the future. In this way, the Partnership became a *co-produced learning network* that brought together not only climate service professionals, but also a Tribe and community to support each other's work and increase potential positive impacts of climate change adaptation planning and mitigation in the context of the local vision of sustainability across a broad geographic and temporal scope. Figure 7 shows actions and processes that lead to a co-produced learning network.

## Conclusions

In this paper, we have presented an instrumental case study (Stake, 1995) analysis of a research partnership among Indigenous and non-Indigenous partners in a rural community in Southeast Alaska. In line with Stake (1995), our aim was to learn about the Ellam Yua co-production process by thoroughly understanding the particulars of the Kake Climate Partnership. Co-authors carefully recorded and interpreted the co-production process over 2 years in the context of a single research program. While our aim was not to generalize about co-production based on our single case study, we have described the context and key features of our work that may be applicable to other co-produced climate services programs.

Stakeholders and practitioners in Alaska are calling for climate science that is more inclusive, transparent, collaborative, and accessible (Knapp and Trainor, 2013). In this paper, we have demonstrated how co-production explicitly designed for application in partnership with Indigenous communities is a transformative way of conducting science which holds great promise. When projects are meaningfully co-produced among academics, Tribes, communities, tribal corporations, schools, and other organizations, it is possible to: focus research and adaptation planning on topics that are most relevant for local people (Kipp et al., 2019); pursue multiple objectives simultaneously[3] leverage funding sources and capacity from multiple entities[3] and produce more usable science (Dilling and Lemos, 2011; Lemos et al., 2012) to maximize actionable outcomes.

3 E. Figus personal observations, 2021.

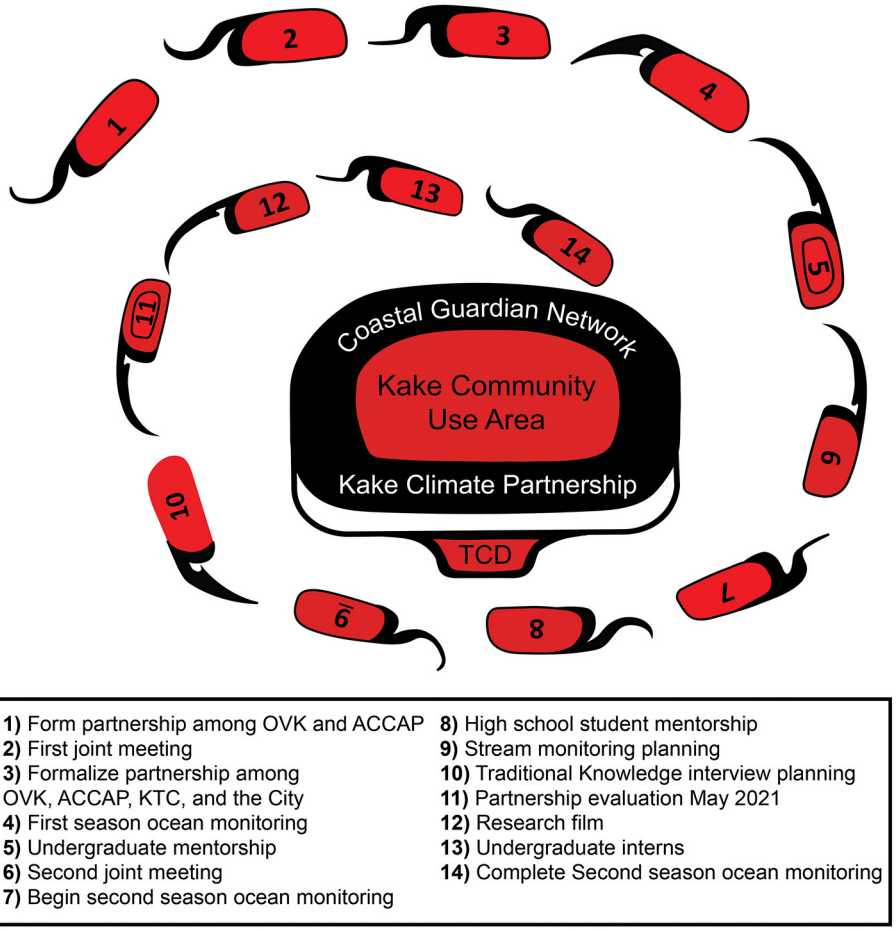


FIGURE 7
Traditional Tlingit formline drawing techniques to display actions and processes that lead to a co-production learning network. The large ovoid in the center of the figure represents the center of the eye. The Kake Climate Partnership forms the base of this central ovoid, and acts as a seed for the future Coastal Guardian Network (see Table 2). The Coastal Guardian Network is situated across the top of the central ovoid, as a goal for the future. The 'TCD' stands for the Tribal Conservation District (see Table 2), which has a root connection to the ovoid in the eye and supports everything above it. The Kake Community Use Area is in the innermost ovoid, as the central point of all efforts. Each small ovoid with a tail on it is unique and symbolizes a main event from the first 24 months of the Kake Climate Partnership—actions partners have taken as a team to build the Partnership and support the long-term vision in Kake. Each small ovoid with a tail is numbered. The numbers correspond to a key underneath the spiral that displays descriptions of each major accomplishment of the Kake Climate Partnership during the 2 years of this study. Artist credit: B. Ki'yee Jackson; digitized by M. Rhodes-Reese.

We found co-produced climate services work conducted in authentic partnership with an Indigenous community and Tribe involved:

- establishing and abiding by shared principles and expectations;
- focusing on local priorities, local values, workforce development (NCAI, 2020a), and local leadership in research;
- upholding data sovereignty and intellectual property for all partners; and
- allowing academic and agency partners to play a supportive, boundary spanning role rather than a leadership role (Bartlett et al., 2012; Bednarek et al., 2018; Reid et al., 2021).

This work required expanding interpretations of research to include centering local workforce development while harnessing scientific expertise and seeking guidance from Indigenous experts. To achieve success, outside partners trusted and followed Tribal and community leadership. The outside partner (ACCAP) also acknowledged that climate change and climate services are just one part of larger Tribal and community visions and needs.

Using a case study of the Kake Climate Partnership, we have shown how co-production can be used to provide climate

services through facilitation, support, and boundary spanning. OVK, KTC, the City of Kake, and ACCAP built a deliberate and equitable partnership, blending cultural and scientific elements of climate services (Benson et al., 2020) and blurring the distinction between producers and consumers of climate information (Dilling and Lemos, 2011). We have described our application of co-production over a 24-month period and reflected on linkages between the Ellam Yua framework and climate services in Kake. Deliberate and reflective application of this model through partnerships achieved relevant and useful climate services in Kake and could likely do the same elsewhere. Most of the challenges faced during this study were typical of any collaborative research, and we believe those that were atypical could be resolved by lengthening the timeline to be 5–10 years, instead of two. Aligned with Sikuaq Erickson (2020), we recommend that future efforts to co-produce climate services through research, adaptation planning, and mitigation be institutionalized and maintained over decadal, not annual, timescales. Research programs with five or more years of funding are well-situated to develop such longer-term plans for co-production of climate change research and adaptation with Tribes and communities.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

BKJ and EF led the field projects described in the manuscript. EF created the monthly updates and monthly logs used in the manuscript, conducted reviews of monthly updates, text analysis of monthly logs, and wrote the first draft of the manuscript. ST supervised the research, contributed to the framing, organization, and writing of the manuscript. BKJ created all artistic contributions (Figures 6, 7). BKJ, EF, and ST revised and approved the final draft, contributed to the objectives put forth in the manuscript, jointly wrote the outline, and contributed background literature to inform the findings described in the manuscript. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

This study was conducted in partnership with Kake Tribal Corporation, a for-profit entity. Kake Tribal Corporation

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2022.885494/full#supplementary-material

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