



“Do you collect data to give to the university or do you do the work to benefit people?”: Indigenous Data Sovereignty in Environmental Contexts

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ABSTRACT

This paper analyzes the current practices of Indigenous data sovereignty in environmental research and activism in the United States, as known by the settler government. The CARE principles are a widely adopted set of guidelines for Indigenous data sovereignty with guidelines being collective benefit, authority to control, respect and ethics, yet there exists little detail on current practices of operationalization and implementation of the CARE principles. This research specifically identified opportunities to further clarify how environmental data can be managed in accordance with the CARE principles. Using current literature, we examine how sustainability and Human-Computer Interaction (HCI) research could better incorporate Indigenous data sovereignty and governance. Through three interviews with Indigenous environmental practitioners, we use inductive and deductive analysis to understand current thoughts and practices. In a forestry analysis case study with the Penobscot Nation, we examine specifically how the CARE principles could be implemented into a research project. The interviews and case study reveal design considerations such as emphasizing roles in responsibility and ethics to be taken into future HCI research involving Indigenous data sovereignty in environmental contexts.

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1 INTRODUCTION

Many Indigenous communities hold a deep connection to their land, to their traditional ways of connecting to the land and to the knowledge about the land that has been passed through the generations. Knowledge that might be considered “environmental” in a non-Indigenous context may hold multiple forms of importance and sacredness for Indigenous nations. Indigenous lands and viewpoints are critically necessary to help fight the climate crisis

through incorporation of traditional knowledge and Indigenous science. For example, worldwide “Traditional Indigenous Territories encompass up to 22 percent of the world’s land surface and they coincide with areas that hold 80 percent of the planet’s biodiversity” [40], making a clear case for Indigenous land management and stewardship. Additionally, front-line Indigenous activism in the United States and Canada “has stopped or delayed greenhouse gas pollution equivalent to at least one-quarter of annual U.S. and Canadian emissions” [16]. These calculations prove the very real impact of Indigenous environmental action, yet these numbers exist along with the incalculable spiritual, cultural, and intangible importance of land and the environment to Indigenous communities. Employing Indigenous data sovereignty in environmental projects will help tribes better protect their valuable cultural knowledge like locale-specific land management techniques and build the technical skills and infrastructure in their own communities. Investing in Indigenous communities by implementing Indigenous data sovereignty will provide better climate solutions for all of us while respecting the priorities and leadership of knowledge holders and stewards.

Through this paper, we show HCI can utilize Indigenous data sovereignty to better create climate solutions with Indigenous communities. In the related works section, we demonstrate how Indigenous data sovereignty as a field attempts to include environmental data in its purview but has not formally articulated concrete principles for the environmental context. We also consider how Indigenous data sovereignty has been used in environmental work and HCI. Based on three interviews with practitioners working in the Indigenous-led environmental space, we reveal how current experts in the field think about the CARE principles [3], the underlying principles of Indigenous data sovereignty. Through these interviews, we demonstrate the strengths of Indigenous data sovereignty in naming often unformalized principles of collective benefit and responsibility and an area of potential growth around addressing science communication with partner communities. In a case study of mapping forestry growth with the Penobscot Nation, we illustrate how themes from the interviews can be operationalized into actual joint research with Indigenous nations. Lastly, we advocate for increased exploration of environmental case studies within the realm of Indigenous data sovereignty to help better develop new guidelines.



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Table 1: CARE Principles

Collective Benefit	Authority to Control	Responsibility	Ethics
For inclusive development and innovation	Recognizing rights and interests	For positive relationships	For minimizing harm and maximizing benefit
For improved governance and citizen engagement	Data for governance	For expanding capability and capacity	For justice
For equitable outcomes	Governance of data	For Indigenous languages and worldviews	For future use

2 RELATED WORKS

This research relies heavily on how the CARE principles can be used in environmental research and how other HCI research fails to use the CARE principles. This section will detail the theoretical underpinnings of (1) Indigenous data sovereignty through the CARE principles, (2) how Indigenous data sovereignty interplay with environmental research, and (3) the need for more incorporation of Indigenous data sovereignty in current HCI research.

2.1 Indigenous data sovereignty + CARE principles

In 2007, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) formalized the inherent sovereignty that Indigenous communities have practiced since time immemorial [28]. The sovereignty in UNDRIP is expansive; recognized in Article 31:

Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. [28]

Within these categories, data becomes a key component to manage and exercise sovereignty. Therefore, to try and understand the impact of data on Indigenous communities and UNDRIP, several researchers in 2015 came together in a workshop [41]. At the workshop, they came up with the concept of Indigenous data sovereignty— a way Indigenous nations could use, control, and apply data about and related to themselves [23]. Following this 2015 workshop, the field of Indigenous data sovereignty has grown including the publication of two full-length volumes [23, 50].

In addition, regional and country-wide organizations have been founded to advocate for Indigenous data sovereignty and governance in their own communities, many of which are members of the Global Indigenous Data Alliance (GIDA), an international network founded in 2019 to promote “Indigenous control of Indigenous data” [1]. GIDA developed the CARE principles (collective benefit, authority to control, responsibility, and ethics) to operationalize the usage of Indigenous data sovereignty into governance [9]. For all the sub themes see Table 1. These principles are the most complete framework for operationalizing Indigenous data sovereignty. These principles, taking inspiration from various Indigenous data sovereignty definitions, sought to be more people-oriented and

purpose-oriented principles than mainstream data principles [8]. In addition to the CARE principles, many practitioners also call for the use of FAIR principles for data cycle management along with CARE [9]. With the development of these formal principles, there exists a need to implement and use CARE principles in the field.

2.2 Indigenous data sovereignty and environmental research

In definitions and missions of Indigenous data sovereignty, the three member alliances of GIDA all express some coverage of environmental data from Indigenous lands. For instance, land is mentioned by the United States Indigenous Data Sovereignty Network definition [29] and Te Mana Raraunga (Aotearoa/New Zealand) assert that data sovereignty is part of their “inherent rights... by virtue of our inalienable relationships with the land, water and the natural world” [32]. The Maïam Nayri Wingara (Australia) takes a more broad scope on environmental data by including data from “any format or medium, which is about and may affect Indigenous peoples both collectively and individually” [52]. From these definitions and missions, it is clear that environmental data plays a role and is actively sought from Indigenous data sovereignty organizations. However, in the two definitive volumes on Indigenous data sovereignty, *Indigenous Data Sovereignty and Policy* [50] and *Indigenous Data Sovereignty: Toward an Agenda* [48], no chapter directly deals with implementation of Indigenous data sovereignty in the environmental area. Instead, the books focus more on other areas such as demography and health.

Researchers have pointed out how operationalization of the CARE principles for environmental research is a necessary goal. In one of the most detailed works on implementing Indigenous data sovereignty and governance calls for three actionable goals for embedding Indigenous data sovereignty into environmental research:

- *Educational opportunities are offered to Indigenous groups so as to be aware of their inherent data rights and mechanisms to protect their environmental data;*
- *All universities, scientific, environmental and research institutions, settler governments and government agencies formally endorse the CARE Principles for Indigenous data governance;*
- *All partnerships between Indigenous groups and settler organisations and institutions in the myriad fields of environmental research develop clear data agreements. [51]*

The authors also walk through three case studies in prescribed burning, GIS, and marine research. In the case studies, the authors demonstrate that without properly associating the Indigenous worldviews into environmental research that often scientific research will exist in opposition to traditional knowledge's original, cultural functions [51].

2.3 Indigenous data sovereignty in HCI

Authors in human-computer interaction have long sought to design useful technologies for marginalized populations and also understand how marginalized communities use technology for their own benefit. In respect to Indigenous communities, researchers have organized Indigenous HCI workshops [24] and called for intentional co-design of new technologies with Indigenous communities [31]. However, theoretical [25, 53] and dissemination [54] challenges still exist when conducting HCI research with Indigenous communities. Rich literature incorporating HCI and Indigenous data sovereignty exists outside of the North American, particularly in Aotearoa New Zealand, including Bowen's work on how to use HCI and participatory methods to design IoT devices with Māori forestry workers [6, 7] and how collaborative software engineering projects with Māori and Taiwi (non-Māori) can work together [35]. Other projects have also suggested design considerations for smart cities incorporating Indigenous data sovereignty and more-than-human worldviews [15]. In this paper, we focus on the American context and find space for deeper theorization on how HCI researchers can design systems incorporating Indigenous data sovereignty in North America [47].

More specifically, a search for research regarding Indigenous data sovereignty in a computing context revealed little literature in Association of Computing Machinery (ACM) conferences. The ACM is the largest professional organization for academic computing conferences and journals and often used for scoping reviews in HCI [30]. When we searched the ACM digital library for Indigenous data sovereignty library, we found only 11 results. Within those 11 results, only six were research articles [4, 18–20, 38, 39]. Most of these articles make brief mentions of Indigenous data sovereignty, but none of them are solely about addressing Indigenous data sovereignty in the field; although one article discussed the need for Indigenous views in information and communications technology (ICT) [19]. This lack of focus and analysis of Indigenous data sovereignty speaks to a literature gap and need for more engagement with Indigenous data sovereignty in HCI research, particularly in ACM conferences, because most of the present work on Indigenous data sovereignty exists in the social science domains and other journals.

3 RESEARCH METHODS

Often Indigenous Knowledge has been used for research by non-Indigenous scholars who leave and do not report back to the community [44]. In particular researchers frequently center "disparity, deprivation, disadvantage, dysfunction and difference" [49] or damage [43] in Indigenous communities rather than celebrating knowledge and cultural wealth. The two authors of the paper write with self-reflection on the ways that our identities and heritage

impact our positions and responsibilities. The lead author identifies as a settler-researcher of Hong Kong Chinese, Turkish and European descent. The second author identifies as a descendant of enslaved African people in the United States who is still exploring how Indigenous ancestry has shaped her family. Reflecting on our research, we hope to move beyond traditional narratives of deficit but understand how our place in a land grant university inherently perpetuates settler colonial research. Through our research, we seek to use what Tuck calls a "desire-based framework" [43] to paint a full reality of Indigenous data sovereignty in an environmental context, to stay truthful to the realities on the ground but also show ourselves and our participant-partners as full, complex people. Drawing on previous HCI research with Indigenous communities, we also prioritized staying flexible, seeing ourselves as apprentices to participants sharing knowledge, checking humility, and budgeting more time [31].

The research design for this study encompassed two key components: assessing the current state of implementation of Indigenous data sovereignty by practitioners and actively engaging in the practice of the CARE principles. To accomplish these objectives, interviews were conducted, providing an in-depth exploration of the perspectives and experiences of individuals involved in environmental topics related to the objectives of an Indigenous nation. Additionally, the research project involved a case study that focused on collaborating with the Penobscot Nation and utilizing remote sensing techniques in an environmental context. Analyzing a specific project through a case study method is an established way of investigating CARE principles in an environmental project [51]. This case study allowed for hands-on experience and practical application of the CARE principles principles.

3.1 Interviews

The authors sought to identify people for interviews about their experiences with Indigenous Data Sovereignty. To select potential interviewees, we sought recommendations from experts with experience collaborating with Indigenous leaders. We started reaching out to potential interview subjects through identifying people in our network. This included contacting Aaron Slater at the MIT Solve Indigenous Communities Fellowship and Megan Hill at Harvard Honoring Nations Project, as recommended by Prof. Philip Deloria, an academic mentor to the project. Using already established relationships was necessary for response rate and builds on existing theories of relationality in Indigenous research methodologies [45]. The interviewer utilized culturally appropriate techniques such as introducing themselves beyond academic status but also including information about their family's background. The interviews reaffirmed Indigenous cultural standpoint [21] and allowed for storytelling as a part of the interview.

One author interviewed three subjects (see Table 2) to aim to understand how Indigenous environmental projects implement or don't implement Indigenous data sovereignty in their work, how CARE principles are utilized in practice, and how different types of data are thought about and used. Interviews lasted between 42 and 91 minutes. The interviews followed a semi-structured interview format with questions developed using key themes from the CARE principles. The interview protocol was classified as "Exempt

Table 2: Interview Participants

Name	Organization / Project Name	Community	Interview Date	Length (minutes)
Shirley Williams	Whiteswan Environmental	Lummi Nation	October 7, 2022	91
Eva Burk	Food from Fire	Dene Athabaskan (Nenana Native Village)	October 12, 2022	42
Alex Whiting	Native Village of Kotzebue Environmental Program	Non-Indigenous tribal employee	November 21, 2022	45

Status,” following the procedures provided by the MIT Institutional Review Board called the Committee on the Use of Human Experimental Subjects. The protocol meets the criteria for “Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior”... while “any disclosure of the human subjects’ responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects’ financial standing, employability, educational advancement, or reputation” [2]. Participants were given the choice of anonymity and all chose to include their names and affiliations. We honor their choices and name them to credit our knowledge holders. Each participant also consented to recording and transcription and agreed to the specific quotes being used in the public research outputs. Where participants have requested to have certain cultural knowledge not included in research outputs, we have also honored such requests. Due to distance of participants and researchers, the interviews were conducted and recorded on Zoom before being professionally transcribed. Transcriptions were reviewed for revision, particularly around technical and Indigenous terminology corrections. Further, interview participants were compensated with either a donation to their organization or gift card worth \$50 USD.

Interview analysis started as an inductive method primarily using grounded theory, not unusual in HCI-related research [11, 12, 36], but themes were not emerging and the interviews were too disparate. From there, we turned to deductive analysis, another well-accepted qualitative analysis to test a pre-existing theory [26]. The CARE principles and their associated sub principles (see Table 1) served as the themes during the deductive analysis. Throughout the coding process, one author did the majority of coding but met often with the other author to go over choices and inconsistencies. The CARE principles served as the theoretical framework to compare with case study findings.

3.2 Case Study

The case study with the Penobscot Nation, a Tribe in Central Maine, was modeled as a singular exploratory case study [55]. This provided an avenue to test themes and reaffirm theory found in the interview results. The case study was a reflexive practice in how CARE principles could be implemented in an environmental project in an American context, modeled on a previous Australian example of implementing the CARE principles in “data collection, integration, analysis and translation practices” for Indigenous Cultural and Natural Resource Management [33]. The example found that data

governance mechanisms should be a foremost priority in projects and that “ethics, power and rights underpinning the CARE principles also need to underpin researcher efforts to ensure data analysis and outputs” [33].

The case study with the Penobscot Nation consisted of using Landsat data to conduct a routine analysis on forestry parcels owned by the Tribe. Landsat data was used to measure normalized difference vegetation index (NDVI) to “quantify vegetation greenness and ... [understand] vegetation density and [assess] changes in plant health” [27]. NDVI was compared across a decade-long period of 2009 and 2019 to help the Tribal forestry manager identify different areas of growth and perform timber stand improvement (TSI) to “improve the vigor, stocking, composition, productivity, and quality of forest stands” [37]. Tribal parcels are used as an existing economic development tool. An example analysis is shown in Figure 1. The technical findings in the environmental project are not of the key message of this paper. Rather, we write a case study narrative on the process with the Penobscot Nation to synthesize the practicality of themes from the interviews. The narrative explores how the CARE principles can inform environmental research partnership and be enriched with findings from the interviews.

Grindstone

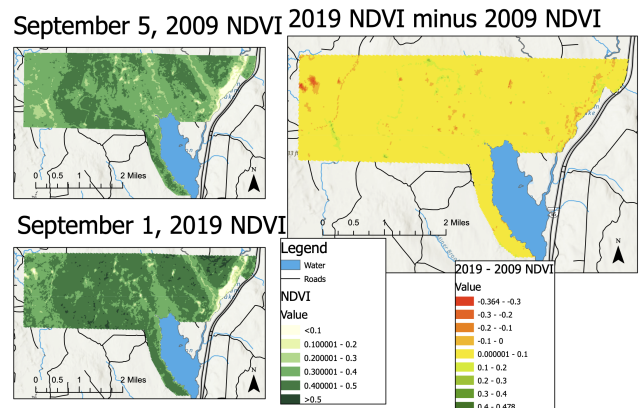


Figure 1: NDVI Results for an example parcel for the Penobscot Nation

4 FINDINGS

We present our findings separated into what we learned from practitioners through interviews and through our experience engaging in an environmental case study. Through each section we breakdown our findings through each CARE principle.

4.1 Interviews

Through interviews with three practitioners, we sought to understand how people currently implemented and thought about Indigenous data sovereignty and the CARE principles. We present our most important finding from our attempted inductive analysis followed by a deductive analysis using the CARE principles.

4.1.1 Initial Theme.

Community Grounded Science Communication. The initial work to identify themes inductively from the interviews revealed a concept that data itself is often not useful for a community. However, interview participants prioritize creating community relevant science communication products. Eva Burk, who along with running Food From Fire is currently a Master's student, said

So in your research, they [formal funders] want you to collect the data and make a report that is really only read and seen by people within the university system...and this is why [her project] it's taking longer...if you wanna do research that benefits the community, then you have to also give the information back. So I need to prepare these concise fact sheets because they don't wanna read scientific publications... Like 2000 pounds of fish, 1000 pounds of...these really kind of larger numbers. That's what the community can use... So it's really like, who is your end user of the data? And how are you analyzing and communicating that data to the end user? And so for us, that has to be storytelling.

Alex Whiting also commented on the usefulness of scientific reports being accessible to a community:

So when we do research projects, in theory, we have access to all the data collected. But in some cases that data really doesn't do us much good like if we're using passive acoustic monitors to record marine mammals, having those acoustic files is not going to really do anything for us. The same like when we satellite tag seals and we could totally have access to all the satellite data...but again that's not really going to do us any good. So in a lot of cases we're not really caught up in what happens to the data as much as what we want to make sure is that the information, the data is translated effectively so your average person on the street in the community can understand what we're doing...One of the things that is a priority for me when we do research... one is to publish scientific papers so that the information we collect can be used in things like NEPA Documents...but published scientific literature doesn't do a whole lot for the community because your average person doesn't sit around reading scientific journals... And so what I also make sure is that we are able to translate our research again into visual things like posters and the videos like the

animated seal and ice map...So I have two focuses when I do research. One is to get published in peer-reviewed journals, but the other and just as important aspect is to make sure that we develop aesthetically pleasing user-friendly products that are easily digestible by your average person.

In these statements Alex Whiting and Eva Burk comment on how formal science papers or grant reports are not of much direct interest to the people they are serving. These documents serve the indirect purposes of obtaining funding to continue projects and providing citable documents for governmental environmental planning. However, Burk and Whiting cite specific strategies such as fact sheets, newsletters, videos, storytelling, and maps as communication products that are useful to community members. These documents are an added layer of research responsibility beyond including Indigenous worldviews in formal academic publications. In addition to traditional research outputs, community grounded science communication should also be a part of a research plan.

4.1.2 Deductive Analysis.

Methodological Shift. Themes were not present in the inductive analysis; thus a methodological shift was necessary. While we could have chosen to take a hybrid approach through methods like thematic analysis [13], deductive analysis was a method that would be more rigorous for asking whether the theoretical framework of the CARE principles was effective for describing factors that arose in practice.

CARE Principles. The CARE principles were applied as a theoretical framework to guide analysis of the interview data because the CARE principles were the most prescriptive way of understanding how Indigenous data sovereignty was articulated by activists. We chose the parent codes to be the overarching CARE principles and the children codes to be the sub principles. For a visualization of the code structure see Table 1. We conducted a full deductive analysis of the interviews and found the most developed themes in the interviews centered on responsibility (22 mentions), collective benefit (19 mentions), and authority to control (17 mentions). By far, ethics was the most unmentioned CARE principle with only 4 mentions.

Collective Benefit. The theme of concern with collective benefit came up repeatedly. Indigenous peoples do environmental work because it is core to their communities and ways of life. Shirley Williams described herself as a "vision keeper" and how Whiteswan Environmental's Digital Ecocultural Map "bring[s] to life the dream of our visions, our village sites, our camps, our reef net locations and our 13 Moon Food Sovereignty in the Salish Sea" so future generations can be present and practice once again. Eva Burk, matter-of-factly described her project saying they were "just adapting to the climate change in Alaska and learning how to grow within our season." Alex Whiting said when starting his Environmental Program found it "natural for me to combine Western science with Iñupiaq values and Iñupiaq Knowledge and the Indigenous Knowledge." All of the participants were invested in creating better futures for their community through collective benefit.

While none of them used the term collective benefit directly, all participants felt the need to do their work to better their community. Whether that was physically distributing food to community members or representing their tribes on committees, they had an obligation to do what was in the best interest of their tribe. This was demonstrated even by the interviewee who did not work directly for their tribal government. The fact that the term collective benefit was not named speaks to how doing work for the good of the community is interwoven into every practitioner's work. The naming of collective benefit by the CARE principles makes the nation-driven nature of the work legible to non-Indigenous and outside scholars and stakeholders.

Authority to Control. Authority to control refers largely to data access, including conducting analysis in line with Indigenous control. While all participants thought about *governance of data*, participants were very much still in the beginning phases of thinking about *data for governance*. Shirley Williams expressed that the Tribe's sacred responsibility to natural laws and inalienable inherent rights began being ignored and dismissed with the 15th Century Doctrine of Discovery, a papal bull that gave Christian explorers the right to acquire land by 'discovery.' The colonial policies that followed led to the fear of "exploitation, cultural appropriation, and intellectual property violation" as described by some tribal elders. Therefore, Williams asserts assimilation to written documents, such as the "MOU that we need to create" is necessary to document the desire to move forward equitably. Whereas Eva Burk more broadly speaking about her data and collaboration with a class building a website mentioned,

we don't necessarily want any old Joe Blow from the internet who can Google on and look at some of this really... To us, is we need this information for ourselves as tribes, but is it going to benefit us out there? So, we're thinking, that was a case in that class where we designed a website where one of the first things that came to mind was this needs to be password protected.

These mentions of *governance of data* did not fit into normative definitions of data governance (not to be confused as *data for governance* which refers to data-driven policy making) that rely on nation-led Indigenous protocols around data that are used in the CARE principles [8]. It is also worth mentioning that each of the participants who are beginning to consider *governance of data* are nonprofits that work in collaboration with their communities, tribal governments, and corporations. Alex Whiting, alternatively, works for the Native Village of Kotzebue. The evidence appeared to indicate that Whiting's experience included a more developed sense of data governance. This may be because the environmental research in Kotzebue must be signed off on by the Tribal Council. This trend is also reflected in the literature involving Indigenous data governance that outlines Indigenous data governance extends beyond Native Nations into non-tribal arenas like federal law, guidelines, urban, inter-tribal, and supra-tribal areas [10]. There is still much room though to better articulate how Indigenous data governance could work with Native-serving and led nonprofits with self-produced and community produced data without formal data agreements with tribal governments.

Responsibility. The most mentioned sub-themes of responsibility was *expanding Indigenous languages and worldviews* and *expanding capability and capacity*. These mentions by the participants were largely about their responsibility of how their projects should positively influence their community. Alex Whiting described how combining Indigenous Knowledge and Western knowledge paints a larger reality of the world,

[F]or ecology anyways, Western science can only go so far in coming up with a description of what actually is reality, whereas Indigenous Knowledge has a whole another deep set of information that when combined successfully in the right way with western science the reality that you're describing is a lot closer to what actually is occurring.

The privileging of Indigenous Knowledge with Western science allows Indigenous worldview to be expanded given epistemic equivalency. To expand tribal capability, project members are trying their best to pool together their skills. Eva Burk described an effort where people on her team are "all learning together and that's the environment that makes people jump in because they're like, we each know a little bit and we're sharing and we're making it successful through the collective effort." These instances show how practitioners are acting out their responsibility to their community through the resources. In the literature, responsibility is more tightly defined as "[t]hose working with Indigenous data have a responsibility to share how those data are used to support Indigenous Peoples' self determination and collective benefit" [17]. The definition reads as assigning those outside the community or stakeholders the responsibility in a research partnership. What would responsibility for practitioners and rightsholders doing research with their community look like?

Ethics. Ethics was the least mentioned principle in the interviews. Many of the mentions were about historical injustices or previous experiences with unethical research. Shirley Williams mentions how it took settlers years to learn to operate Lummi reef net fishing technology, then it was outlawed and later required license permission for tribal usage. For Alex Whiting, due to the Tribe's past experiences with unethical research, he was initially tasked with creating a research protocol. This allowed the Tribe to set "expectations from the beginning about how to do ethical research and... get clear commitments from the researchers about what they were going to give back to the community." The ethics mentioned in the interviews were about how ethics being crossed negatively impacted tribal communities. There were no mentions of how outside researchers positively used ethics in their research with tribes. Indigenous communities and rightsholders think about ethics, but ultimately, stakeholders and outside researchers are more obligated to think about ethics throughout the research process [10].

4.2 Case Study

4.2.1 Collective Benefit. The principle of collective benefit, as evidenced in the interviews, was a topic all people felt strongly about; yet it could be difficult for people to articulate. For example, the forestry tracts for Tribal members to make a livelihood off of are deeply important for *inclusive development and innovation*, but these connections were not exactly clear until we were wrapping up the

project. It can be difficult to articulate collective benefit because tribal governments work to serve and strengthen their nations. All work done by tribal governments would have the intention of collective benefit. The naming of collective benefit for the CARE principles helps to make the reasoning for the work more legible to non-tribal stakeholders like ourselves.

In the project, there were no clear descriptions of how the project would work towards *equitable outcomes* or *improved governance and citizen engagement*. From the interviews, we learned that communication about scientific materials, in this case, the maps produced with Landsat data, can be difficult or unimportant to a non-technical audience. This means the maps may not be directly impacting citizen engagement, since we did not talk to general tribal members. One author on a previous project found the general tribal member interest was more in cultural findings from forestry data, such as the location of important tree species, rather than general forestry conclusions. This is an example where governance interests and citizen engagement may diverge—general citizenry may have different priorities than a natural resource department invested in general forest health.

This leaves much room to think about how collective benefit can be articulated into specific niche projects for the environment, especially when the work is technical. The main audience of our work was forestry managers, people with technical knowledge who make important decisions about tribal lands. When work does not directly engage tribal members, how broader outcomes around *improved governance and citizen engagement* and *equitable outcomes* may be less important or prioritized. This reflects how Indigenous data governance is currently at a starting point and “there is no wrong place to begin nor any wrong place to focus attention and resources” [10].

4.2.2 Authority to Control. Similar to collective benefit, in the authority to control category the easiest subsection was the first—*recognizing rights and interests*. For me, this meant working to check in with our contacts at the Penobscot Nation regularly and giving them the final say in how to share and write about our work, including this paper. This reflects the suggestion to “[e]xplore the complexities of individual and collective rights in relation to Indigenous data sovereignty [and] [e]xplore the relationships among ethics, law, data governance in relation to Indigenous data” [10] as a responsible stakeholder.

However, *recognizing rights and interests* is more difficult when talking about remote sensing data such as Landsat data utilized in this case study. There exist many existing tensions between how remote sensing is conducted currently and tribal sovereignty over land. Currently, while Indigenous data sovereignty seeks to establish tribal control over land and resources, implementation of Indigenous data sovereignty over remote sensing data is unlikely due to international norms around satellite monitoring. When using remote sensing data with Indigenous communities we find early and honest conversation between researchers about availability and openness of data be highlighted. We also find more collaborative projects centering remote sensing and Indigenous communities could be helpful for navigating policy implications of remote sensing and Indigenous data sovereignty such as the Indigenous Peoples Initiative at NASA.

The other two subsections under authority to control are *data for governance* and *governance of data*. The remote sensing data for tribal lands is mostly publicly available from a combination of NASA and the tribal government. However, it is the analysis and combination of the data that makes it possible to govern, making decisions about how to care for parcels and forests. In data governance, there is much room for growth on the project. When we initially contacted the tribe, we expected a lengthy legal process, including potential institutional review boards [22], memorandums of understanding, or non-disclosure agreements. However, upon speaking about the project and our intentions, we were met with surprising ease of access to data and trust to carry out our work. This included being provided GIS files and previous examples of maps without any formal paperwork. To better implement data governance, the Penobscot Nation could better formalize policies around data procurement for outside researchers.

In further conversations with the Tribe, we learned environmental and GIS data have been subject to conversations around Indigenous data sovereignty before. For example, the tribe has negotiated with the state for the removal of certain data from the state’s data portal for culturally sensitive reasons. Yet, it has been reported that some of the data is still accessible through older websites and portals. A larger vision for control and access to data would strengthen how data governance could be practiced in different departments of the Tribe, especially with environmental data, which is often owned and controlled by various stakeholders from the tribal, state, and federal levels. A place for a rightsholder to start when considering data sovereignty and governance is “[d]evelop[ing] tribe-specific data governance principles... policies and procedures” [10].

4.2.3 Responsibility. The tertiary principle of the CARE principles is the responsibility “to nurture respectful relationships with Indigenous Peoples from whom the data originate” (Carroll et al. 2020). This responsibility falls onto me, as the outside researcher and stakeholder. Through this work, we sought to have open communication about our abilities and timeline for the work to create a *positive relationship*. The responsibility principle also calls for *expanding capability and capacity* and *Indigenous languages and worldviews*. However, through our research, we were not completing scientific analysis the Tribe did not have the capability to do. The Penobscot Nation GIS Specialist, was particularly adept and helpful during the project. We were doing an analysis that was needed but the tribe did not have the time for at the moment. Further, as echoed in previous sections, our work was largely technical, and we did not see the opportunity to include *Indigenous languages and worldviews*. Following the Australian example, we could have set up an Indigenous advisory committee which could have infused more Indigenous languages and worldviews into our data analysis [33]. Our analysis was provided so that the tribe could use it to inform their work which takes into account their worldview. When talking to the tribe about the project, there did seem to be a separation between cultural heritage and natural resources as departments and worldview standpoints.

However, the responsibility section did not address how non-tribal members in the tribal government operate within these principles. Some of our contacts at the Penobscot Natural Resource Department are tribal employees but not tribal members; some

were members of other tribes and some were non-Indigenous. In the interview chapter, we briefly touched on the audience question of the CARE principles, and during the case study, this came up again. The principles better articulate who the audience is and how Indigenous peoples can use the principles for themselves. In our interactions with the tribe, we knew we could utilize some of the CARE principles as an outside scientist and stakeholder. Tribal employees, regardless of tribal membership, have a responsibility to carry out work in the best interests of the tribe, but it is sometimes unclear if technical employees, such as a GIS specialist, have the knowledge or expertise to carry out responsibility for *Indigenous languages and worldviews*. This again, points out that clear audience and stakeholder guidelines are necessary for the proper operationalization of the CARE principles.

4.2.4 Ethics. As iterated in the interview section, it seems that ethics principles were mostly meant for outside researchers. In the project, as with the responsibility principle, the majority of the work fell to me as an outside researcher. We were able to work to *minimize harm, maximize benefits*. A model of this subprinciple in data analysis is to take

“an iterative approach to data analysis, conducting on-going checks to ensure that the results of the analysis remained policy-relevant and would minimise harm and maximise benefits for Indigenous communities. Indigenous representatives were involved in this iterative process as draft findings were shared with the inter-agency Steering Committee for feedback and review.”
[33]

We conducted an abbreviated version of this approach. One author sent individual 2009 and 2019 maps to check with the tribal forest manager for verification to make sure our work was policy-relevant and beneficial. Then the author would proceed onto conducting a subtraction analysis. There was less emphasis on minimizing harm since we were working with mostly public data that was already released by the tribe. We also found it difficult to *promote justice* in our work. We were not sure where justice fell into the short project and how to encourage larger visions for addressing power and resource imbalances. The Tribe pre-established the need and process for the analysis through a previous intern. The third sub-principle *for future use* was highly important, though, because documentation and data sharing for potential future analysis were necessary. We completed this through data documentation and sharing with the tribe.

5 DISCUSSION

While the concept of Indigenous data sovereignty is relatively new, Indigenous peoples have been gathering data since time immemorial, as record keeping and data were essential for them to learn about and survive in their environments. Examples of such data gathering and collection include winter counts, totem poles, and khipus [34, 46]. These forms of data collection are ancient and well-practiced. Data collection and data science are not new to Indigenous peoples. However, there are still challenges to prepare for in the future as evidenced in the interviews and case study. We observed that Indigenous communities consistently embraced the concept of *collective benefit*, actively considering its implications.

However, we also identified a need to establish formalized *authority to control* practices involving diverse stakeholders and rightsholders. Moreover, we recognized that stakeholders should assume the responsibilities of both *responsibility* and *ethics* from the outset of the research process. While tribes and practitioners are well aware of Indigenous data sovereignty, formal implementation of guidelines like the CARE principles remain a pressing issue as found in the interviews. Through our analysis on interviews and the literature, we also found the CARE principles worked at a high-level cross-domain but there are unique challenges to the environmental field such as the tensions regarding remote sensing discussed in the findings. Fine tuning the CARE principles and best practices for subdomain areas such as environmental research could result in more actionable and clear guidelines.

Another factor in Indigenous data sovereignty as a field is defining Indigenous as well. Throughout this study, we acknowledge that Indigenous communities are diverse and exist in varying circumstances. This is particularly true given the tensions of federal recognition, disenrollment, and derecognition. In our study, due to disciplinary constraints we limited our geographic area to the United States, and in selecting participants we chose to have a wide and expansive definition for self identification. However, through working with our networks, what resulted was only working with federally recognized tribal members and employees. This limits our findings to understand Indigenous data sovereignty through a very specific set of American-specific legal standards for tribes. This also means rightsholders, when they are federally-recognized tribes, have more legal jurisdiction when deciding issues around principles such as authority to control. Even with these legal protections tribes often struggle to control and access data that pertains to them. For example, in a legal analysis of Indigenous data sovereignty, Tsosie explored environmental challenges that Navajo Nation faced in monitoring and enforcing laws surrounding uncapped oil wells and abandoned uranium mines [42]. Moving beyond working with just federally recognized tribes as HCI researchers, we will have to find creative ways to implement Indigenous data sovereignty work in Indigenous communities who are state-recognized or unrecognized. Further, most of the current Indigenous data sovereignty literature, including this study, focuses on Anglo-settler states. Yet, there are Indigenous peoples who have experience(d) varying models of colonialism that would benefit greatly from more Indigenous data sovereignty work exploring their contexts and needs. Scholars have started asking these questions, for example, in the Basque Country [5] and Mexico [14]. In HCI, we aim to design and work with those on the margins and must remember differing Indigenous communities also experience a myriad of challenges that might confront us.

Another disciplinary factor we faced in this study was that we worked primarily from a social science background. While we engaged in technical analysis using GIS, we used self-reflection and interviews as our primary method of analysis in understanding how people were thinking about Indigenous data sovereignty. Our methods were rooted in social science methods, particularly qualitative interviews. None of this study engaged with designing new technologies for communities. If more human-computer interaction researchers and computer scientists were to engage with Indigenous data sovereignty, we could better understand technical design

principles to complement the wealth of social science literature on the topic.

6 CONCLUSION

From the two-part analysis of how the CARE principles are currently used in the real world, we found there are several main areas for possible design implications on how to operationalize the CARE principles and Indigenous data sovereignty. Indigenous data sovereignty is key to the self-determination and governance of tribal communities [5]. Primarily, the CARE principles should be adopted by all HCI researchers working with Indigenous communities. Through this adoption, particularly paying attention to responsibility and ethics as researchers we can better bring the CARE principles to adoption and we follow Indigenous leads. Pioneering participatory research methods to introduce these themes early on could result in innovative solutions and approaches. Also, through wider adoption of the CARE principles as technical experts, we can bring more user-centric and technical lessons to the social-science heavy Indigenous data sovereignty field. Additionally, we encourage various case study methodologies in future research to explore Indigenous data sovereignty, with a specific focus on the environmental domain that could result in more formalized practices for stakeholders. This approach will contribute to the formulation of domain-specific principles that can be refined as the CARE principles and Indigenous data sovereignty evolve in scholarly literature.

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