



Science in Indigenous homelands: addressing power and justice in sustainability science from/with/in the Penobscot River

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Abstract

Sustainability science offers an alternative space for research that challenges colonial histories of western science, especially in its orientation to interdisciplinarity and for addressing complex problems through equitable knowledge co-production processes. However, the justice-oriented commitments within sustainability science remain underdeveloped, in particular for centering indigenous research methods (IRM) and promoting decolonization of academic institutions. In this paper, we draw from more than 10 years of experience across three cases of conducting sustainability science in Indigenous homelands. The cases focus on (1) adaptive responses to the Emerald Ash Borer insect which threatens black ash basketmaking cultures and economies; (2) efforts to link science with decision making to protect public health and reduce shellfish bed closures; and (3) collaborative research to support dam removal and river restoration. We identify tensions in science as a discourse, including how sustainability science is uniquely shaped by practices of naming and social constructions of time. We then describe how we engage these tensions through four main commitments to critical praxis, or tailored practices that respond to emergent problems and systems of power. These commitments include centering Wabanaki diplomacy and IRMs, redesigning all stages of research for inclusivity and dialogue, attending to multiple temporalities, and supporting Wabanaki and Indigenous students as leaders and researchers. To conclude, we reflect on how these practices may be adapted to other contexts, histories, and sustainability-related issues.

Keywords Indigenous research methods · Sustainability science · Discourse · Rhetoric · Time · Critical praxis

Introduction

The call for approaches that attend to power and integrate justice and sustainability, especially in the ubiquitous context where scientific research occurs within Indigenous homelands, is increasing in frequency and intensity (e.g., Chapman and Schott 2020; Johnson et al. 2016; Sze 2018). As van Kerkhoff and Lebel (2006) argue, the focus on action in sustainability science comes with a need to address power because “as soon as researchers become concerned with

action, decision making, and change, power can no longer be ignored as it is intimately entwined with the ability to act” (p. 466). Sustainability scientists show a commitment to address power in the overlapping contexts of colonialism and academia. For example, Johnson et al. (2016) highlight the need to attend to Indigenous rights and sovereignty as academic institutions “have unequivocally been part of the structure and infrastructure of European colonial power and its specific impacts on particular Indigenous peoples and their places and institutions” (p. 2). Further, researchers have identified dialogue-based processes for integrating diverse knowledge systems that allow participants to share power and work towards mutual understanding for equitable solutions (Daigle et al. 2019; Tengö et al. 2014).

Scholarship on indigenous research methods (IRMs) expresses a commitment to Indigenous people’s agency, sovereignty, and self-determination, emphasizing how Indigenous and western knowledge systems can be intentionally designed to support these commitments (Chapman and

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Schott 2020; Smith 2012; Whyte et al. 2018). For example, while Nadasdy's (1999) research in Arctic regions points to the persistent power issues related to "integrating" Indigenous knowledge into western science and co-management, more recent efforts associated with the National Inuit Strategy on Research (Inuit Tapiriit Kanatami 2018) show how dialogic research processes can amplify tribal sovereignty and shift colonial power structures associated with science-based policy development (Chapman and Schott 2020).

Despite these examples, there remains a need to learn from how justice-oriented commitments occur in research and how such practices may be adapted to other contexts, histories, types of partnerships, and objectives for linking knowledge with action within sustainability science. While previous scholarship emphasizes dialogue, culture, and communication, interdisciplinary orientations within communication studies, anthropology, and Indigenous studies have only just begun to inform sustainability science praxis (e.g., Daigle et al. 2019; Johnson et al. 2016; Sze 2018). Further, given the pressing need and magnitude of challenges in transforming centuries of colonialism in academic institutions and science, it is essential to understand how to advance a more just sustainability science at the scale of individual researchers, teams, and projects as well as in academic institutions across campuses and contexts.

To this latter point, Sami scholar Rauna Kuokkanen (2007) poses a question that guides our work: "What are the responsibilities of the participants of the established discourse individually—and of the academy as a collective—when it comes to listening to, responding to, and (most significantly) recognizing [Indigenous] epistemes? How can the academy, at the individual and institutional levels, prepare itself to respond to and reciprocate with these worldviews?" (p. 8). As part of this (re)orientation, Kuokkanen calls for a deeply contextual, reflexive, and praxis-oriented approach that centers Indigenous ways of knowing. Her open-ended conclusion emphasizes the slow and ongoing process of "learning to learn" as a way of cultivating shared responsibility and critical, uneasy hospitality that attends inhabiting and transforming academic institutions within Indigenous homelands.

In this paper, we offer a response to the questions Kuokkanen (2007) poses and insights from shaping sustainability science efforts to respect Indigenous knowledge and tribal sovereignty. We draw from our experiences in sustainability science across three primary cases, including efforts to support adaptation to the threat of the Emerald Ash Borer insect to black ash trees, a species that is economically valuable and culturally significant to Indigenous peoples (Costanza et al., 2017; Frey et al. 2019; Ranco et al. 2011); address water pollution that negatively impacts clam harvesters and Wabanaki Tribal Nations (McGreavy et al. 2018); and co-produce knowledge to support decision making about dams

and river restoration (Roy et al. 2018). After defining our methodology and cases, we identify an interconnected set of tensions that shaped these efforts, including how western science functions as discourse, the power of naming, and the influence of multiple orientations to time. We describe a series of praxis commitments to work through these tensions including (1) centering Wabanaki diplomacy (Ranco 2016) and IRMs; (2) designing research to include pilot work, iterative engagement, and dialogue; (3) finding ways to slow down research and create different rhythms of collaboration; and (4) supporting Wabanaki students as leaders and researchers. We conclude with reflections on how these commitments may be adapted to other contexts, histories, and knowledge co-production efforts.

Sustainability science and case study methodology

We use a reciprocal case study methodology (Darke et al. 1998; Yin 2013) to support equitable, inclusive, and reciprocal knowledge co-production (Kuokkanen 2007; Madison 2006; Smith 2012) across three main sustainability science cases. These cases are all situated in the homeland of the Penobscot Nation, as the University of Maine Orono campus sits on Marsh Island in the Penobscot River. The Penobscot Nation is part of a coalition of Wabanaki tribes which includes the Passamaquoddy, Maliseet, and Micmac Tribal Nations. As collaborating co-authors, we have been in continual dialogue about these projects for more than a decade in ways that support cross-case analysis and interpretation (Darke et al. 1998; Yin 2013). We assembled a substantial archive of meeting notes, reflective writing, visual images, videos, presentation slides, and related artifacts that informed the case study insights.

Mitchell Center for Sustainability Solutions

Our ongoing dialogue has occurred through shared affiliations with the Senator George J. Mitchell Center for Sustainability Solutions (hereafter Mitchell Center) (Hart and Silka 2020). Consistent with our reciprocal methodology, we negotiated positionalities through dialogue, with a sustained interest in "a mutual creation of something different and something more from the meeting of bodies in their contexts" (Madison 2006, p. 320). Our multiple identities were interwoven in our interactions and, related to the focus of this paper, our racial and ethnic differences mattered in significant ways. Our identities as Native scholars from Penobscot (Ranco, Daigle, Michelle, Paul, Binette), Passamaquoddy (Altwater, Sutton), and Maliseet (Greenlaw) Tribal Nations and as White settler scholars with European ancestry (McGreavy, Quiring, Benson, and Hart) shaped tensions "that are at the center of dialogue" (Madison 2006, p. 323). Further, differences in knowledge; disciplinary

training; relative familiarity with IRMs; and respective roles as faculty, students, and tribal partners also influenced our process. We practiced reflexivity with host of choices, such as how to hold meetings; invite authorship, aiming for an inclusive definition of writing; and combine dialogue, reflection, and one-on-one conversations to foster learning across difference (Madison 2006).

Emerald Ash Borer case

Our first case focuses on the Emerald Ash Borer (EAB) project as one of the earliest sustainability science efforts in the Mitchell Center. The EAB insect (*Agrilus planipennis*) is an invasive species brought to North America on shipping pallets in the 1990s and was first documented killing black ash trees (*Fraxinus nigra*) around Detroit, Michigan in 2002.¹ The formative stages of the EAB project began in the early 2000s when Daigle, Ranco and collaborators reached out to tribal communities to discuss interests in a report on potential impacts of climate change in Maine (Daigle and Putnam 2009). At these early meetings, many tribal basketmakers and ash harvesters reported hearing stories from Michigan about an insect destroying ash trees. Their concerns about the potential spread of this insect to Maine led to the reformulation of a black ash task force with the University of Maine, Maine Forest Service, and Maine Indian Basketmakers Alliance (MIBA) to address concerns about die-back and health of black ash.

The initial black ash task force meetings were crucial in preparing collaborators for future action, as they provided opportunity to share the latest information from entities such as the United States Department of Agriculture (USDA) Forest Service and Animal, Plant, Health, Inspection Service (APHIS). Scientists and resource managers shared emerging science around EAB and lessons learned from failed attempts to control EAB populations. The participation of tribal representatives from Michigan and New York was essential for information sharing, as tribal participants helped attendees learn about impacts of EAB to cultural practices as well as adaptive strategies such as ash seed collection by the Akwesasne Nation (Benedict and David 2000). These meetings helped foster an emergency rule to ban firewood transport from outside of Maine. At the committee hearing to debate this rule, members of the task force voiced their strong support which became a decisive factor in the rule's passage. When the EAB was detected in Maine in 2018, the rule enabled the state to issue a quarantine regulating the movement of the insect, firewood, nursery trees, and related materials through the infested areas, thereby limiting the spread.

¹ In Maine, black ash is commonly referred to as brown ash.

Safe Beaches and Shellfish case

The second case focuses on the Safe Beaches and Shellfish Project (SBSP), a collaboration with the University of New Hampshire which brought together interdisciplinary researchers with state agencies, nonprofit organizations, coastal municipalities, and shellfish-harvesting communities to link knowledge with action to reduce adverse effects of coastal pollution. The project also intended to connect with Wabanaki Tribes through the Wabanaki Youth in Science Program (WaYS), a leadership and cultural science training program (carr and Ranco 2017) and a research partnership with the Passamaquoddy Tribe at Sipayik though, as we describe in the analysis, neither of these goals were fully realized.

The SBSP emerged in response to myriad social-ecological pressures in coastal communities, many of which are connected to climate change, unsustainable economic development, and colonialism. Increasing coastal development, precipitation events, and polluted run-off contribute to declines in water quality and persistent mud-flat closures. These closures exacerbate the uncertainty in clamming as a livelihood and for subsistence fishing (McGreavy et al. 2018). In addition to partnerships with state water quality agencies, the SBSP explicitly called for research with Passamaquoddy tribal partners to address the impacts of the closure system on Indigenous shellfish harvesters. Michelle, Ranco, and Daigle engaged in a series of focus groups and interviews to assess the impact of closures on Passamaquoddy tribal citizens, community well-being, and cultural practices. The findings form the core of Michelle's forthcoming dissertation research and identify three major themes: (1) equity in fisheries distribution, (2) tribal identity, values, and cultural practices, and (3) appropriate approaches to management and conservation of coastal resources. The focus groups pointed to a lack of consistent engagement by state agencies with Passamaquoddy tribal citizens, the inability of regulators to address the ongoing impacts of colonization and state control on access to tribal fish resources, and the state's lack of interest and respect for Passamaquoddy knowledge and traditional systems of fisheries management. These findings are not surprising; however, they are also not present in most of the written products related to SBSP. Many factors contributed to this disconnect, including how the project did not center Indigenous knowledge nor include Indigenous people in key leadership roles. Research collaborators also made choices in the early stages of the project that centered non-tribal water quality interests. Though researchers attempted to connect across state and Indigenous contexts, the development of water quality decision tools like forecasting models and monitoring systems centered state-based priorities, when Passamaquoddy

partners had different concerns related to water and environmental protection (Daigle et al. 2019; Michelle, in prep; Sutton 2020). Collaborators tried to address these mismatches, but many of the changes came too late to fundamentally redirect the project, so we increased our effort to learn from experiences and avoid replicating the same mistakes in future. The ways in which the SBSP project failed to integrate with tribal interests became an important motivator for our work on the Future of Dams and helped initiate this paper.

Future of Dams case

The third case draws from the Future of Dams (FoD) project which built on existing collaborations to form a new partnership with the University of Rhode Island. The project intended to link multiple forms of knowledge with decision making about dams. There were a host of transdisciplinary research efforts in the FoD (e.g., Roy et al. 2018) and here we focus on continuing efforts to restore the Penobscot River (Opperman et al. 2011) and partnerships with the Penobscot Nation's Department of Natural Resources.

In contrast to the SBSP, the Future of Dams started with the commitment to center Indigenous priorities by focusing on the Penobscot River Restoration effort and involving Penobscot Nation (PN) partners to identify meaningful questions about river restoration and dam decision making. The disparate and negative impacts of dams on the PN can be traced back hundreds of years and the PN Department of Natural Resources led many early efforts to address related river restoration efforts. Their work contributed to the formation of the Penobscot River Restoration Trust in the late 1990s and the passage of the Lower Penobscot Settlement Accord in 2004 which outlined a watershed-based approach to dam decision making (Opperman et al. 2011). This decade-long collaboration eventually resulted in the removal of two dams at Veazie and Great Works, fish passage improvements at Milford and Howland, and hydropower upgrades at six other dams.

Leaders from within the PN provided guidance throughout the FoD to develop a suite of research projects including engaged digital and news media projects to help raise awareness about the PN's cultural science and river restoration efforts (Quiring 2020). We also hosted research dialogues with PN partners to help shape research on participatory dam decision-making processes. Finally, we collaborated with the WaYS program to help Indigenous students gain leadership skills and build relationships with tribal communities and elders, which became central in our decolonizing commitments and which may serve as a key commitment for those who intend to advance just and anti-colonial approaches to sustainability science.

The power of words: addressing science as discourse

The case descriptions help illustrate core commitments in sustainability science that make it a different and potentially more just research space. For example, interdisciplinarity can help question Enlightenment-era binaries that divide subjects/objects and mind/body (Smith 2012). Further, attention to diversity and equity challenges the status quo of exclusion and hierarchy, especially as these patterns privilege scientific expertise, masculinity, and whiteness (Whitt 2009). Finally, dialogue and the recognition of multiple realities transform positivistic assumptions about knowledge that reinforce logics of distance and control (Smith 2012). Dialogic approaches emphasize the mutual influence of researchers and research settings, where "objectivity" becomes impossible. Further, recognizing multiple realities complicates assumptions about cause and effect relationships and challenges linear determinism, especially for imagining possible futures (Adam 1998).

Here, we briefly expand on how western science functions as discourse and then connect with our cases to illustrate discursive tensions. We define discourse as the set of practices that follow rules that shape sense-making (Foucault 1970). Rules and logics guide scientific practices and patterns of authority that then define what counts as science (Foucault 1970). Western science becomes recognizable as a set of activities because of how science is constituted by research practices that are guided by formal and informal rules for how things should be done. For example, submitting proposals to Institutional Review Boards (IRBs) is a common social science research practice guided by formal rules about research with human subjects. These rules constitute ethics in ways that foreclose other options for ethical research practices, such as rules that would directly address the history of racism in "human subjects" research (Lynch 2019). These rules can also reinforce research practices where scientists collect data that are then never shared with host communities (Simonds and Christopher 2013) and science translation processes where knowledge is used to govern and reinforce unequal power in society (Whitt 2009). The constraints with IRBs point to a need for different rules and processes to determine what constitutes ethical research in sustainability science.

Treating science as discourse recognizes that there are many influences that shape how science enacts power, and funding is a particularly powerful influence (Ceccarelli 2013). The pressures for grant-funded research include the need to demonstrate a "return on investment" with faster and higher levels of overall productivity. As the term investment signals, grant-funded research can reinforce neoliberal logics, especially the drive for expediency, efficiency, and control (Winslow 2015). The influence of National Science Foundation (NSF) funding was a consistent feature across all

three cases and serves as an important contextual reference point. Funding for sustainability science is often required to support hiring staff and students for time-intensive projects. Funding to travel, especially in rural and geographically dispersed regions, is often needed to support relationship-building processes. As an economically underprivileged EPSCoR state, Maine is able to apply for Research Infrastructure Improvement grants (RII) which build research capacity but can also reinforce systemic inequities because of the levels of scrutiny and expectations for output. These pressures connect with capitalist and neoliberal forces in the academy, thus reinforcing colonial logics in western science (Kidman 2020).

The influence of neoliberal logics associated with funding sources played out differently across the projects. In the early stages of the SBSP, the team often used the phrase “hit the ground running” as this project had a relatively short duration which reinforced linear and progress-oriented construction of time. These temporal constructions foreclosed other possibilities, such as slowing down, looking at the past to inform present actions, or envisioning multiple possible research futures. Instead, researchers focused on developing a rapid understanding of current state policy for water quality regulation at beaches and shellfish beds and identifying decision makers in state agencies and nonprofit organizations in Maine and New Hampshire. In contrast, both the EAB and FoD had different funding arrangements that changed how neoliberal pressures shaped these projects. In addition to a more critical orientation to this particular issue informed by the previous projects, the FoD project benefited from having a longer grant duration which gave collaborators time to engage in dialogue to iteratively shape research plans and cultivate meaningful engagement with the WaYS program. In the EAB’s early stages, collaborators pursued a small planning grant for scoping meetings with partners to identify research interests. Before researchers engaged with Wabanaki basketmakers, the team identified an interest in mapping basketmaking trees. In the pilot scoping project, they proposed this idea to Maine Indian Basketmakers Alliance partners and learned that harvesters did not need a map identifying tree locations. They already knew much more about the locations, site preferences, and status of these trees than a map would show. However, the pilot phase helped the group identify research questions about how to prepare for the EAB threat.

In addition to extending the amount of time collaborators had to co-define problems, this approach helped address a related bias in funded research to focus on larger-scale problems, like climate change adaptation, but where local level effects and concerns are not well-known or articulated and where the science is not designed to connect with local concerns (Nadasdy 1999). Learning how to frame the problem in terms of local concerns and scientific questions can

help create research that is meaningful across contexts and also requires NSF to shift its funding priorities. The focus on framing also points to one of many ways that language shapes the construction of knowledge.

Naming in sustainability science

Naming is a complex communication process that refers to the use of symbols to call attention to some aspects of reality while ignoring others (Burke 1966). In what they describe as rhetorical colonialism, Stuckey and Murphy (2001) examine how names are “powerful forces, for they are the loci of negotiations over social authority and cultural identity” (p. 75). Naming enacts symbolic legitimacy in how names shape and construct divisions that privilege some forms of knowledge over others (Cox 2010; McGreavy et al. 2013). Further, the erasure and appropriation of Indigenous place names highlights how naming is a power relation that guides how we relate to and inhabit places (Brooks, 2008; Goeman 2009; Na’puti 2019; Stuckey and Murphy 2001). Attending to how names shape knowledge and power is a crucial first step in grappling with how naming constitutes collaborative research projects and, subsequently, how to “uproot settler [names] that drive our everyday materiality and realities” (Goeman 2009, p. 170). Among the myriad practices of naming in our cases, the term “decision maker” became a powerful symbol for constructing symbolic legitimacy and reinforcing state power. Centering decision makers as a category enacts forms of exclusion that may ultimately undermine sustainability scientists’ abilities to meet objectives for knowledge co-production. The meanings that articulate with “decision makers” can reinforce power dynamics which may not serve the interests nor the inherent complexity of sustainability problems. For example, the decision in the SBSP to direct resources towards decision makers who already had a greater degree of power limited the potential for justice-oriented sustainability transformations. Identifying decision makers as a priority also draws a boundary around knowledge production in ways that can foreclose other, and possibly more creative and transformative, objectives. Although there were a complex set of factors that came together to shape differences in these projects, the increased focus on how “decision maker” shaped symbolic legitimacy on the FoD was a key factor in informing choices about research engagements and helped constitute a more fully developed partnership with PN and WaYS.

The power associated with “decision makers” is also constituted through place names, and in our case naming this place the “State of Maine” matters in significant ways. The intention to connect knowledge with decision makers reinforced the power of place names, and especially the “colonial cartographic violence” (Na’puti 2019, p. 3) of renaming this region the State of Maine as an attempted erasure

of Indigenous place names. State-based naming practices construct a geopolitical imaginary, where “spatial ideologies and their narration in popular culture, land and people become seemingly bound and fit into tight containers, in this case the reservation” (Goeman 2009, p. 179). “Decision maker” as a naming practice derives symbolic legitimacy through this imaginary, where Native peoples are not recognized as legitimate actors in state and federal spatial formations and where space itself becomes tied to land. In contrast, other spatial imaginaries, such as those that emphasize water, can “rapidly [churn] us in connection and belonging to ancestors, histories, and environments of these places,” thereby disrupting land centrism and dominant practices of knowledge production (Na’puti 2019, p. 16).

Social and material constructions of time

Similar to how naming shapes knowledge and power, time is also a symbolic and material construct that has a profound influence on sustainability science (Bornemann and Strassheim 2019). Collaborators who work on complex sustainability issues have to balance multiple priorities and their availability for “time consuming” collaboration processes, such as in-depth pilot work and iterative dialogue sessions, may be limited. As the quote marks around “time consuming” signal, the concept that time can be consumed implies a set of assumptions about what time is (Adam 1998). In this example, time is a limited resource whose scarcity is further intensified by intersecting factors, such as the competitive rush to be the first to go beyond the “frontiers” of knowledge (Ceccarelli 2013). While time is often identified as a practical issue, for example the recommendation that researchers need to simply evaluate the amount of time they have for this kind of work, we have come to recognize that this orientation to time is itself one worldview. Other ontological perspectives are already present and necessary to further shift temporalities in sustainability science (Adam 1998; Bornemann and Strassheim 2019).

Funding regimes are powerful forces in constituting timescapes, which we define as an orientation to “the temporalities of life—of change and rhythmicity, timing and tempo, speed and intensity, duration and succession” (Adam 1998, p. 77). Funding regimes are but one of many forces that constitute sustainability science timescapes, including neoliberal pressures in the academy that treat students as customers and the temporal expectations for “customer satisfaction”, institutional norms for productivity, expectations for fundraising beyond grants, and student degree timelines and career pressures. These pressures are compounded by the sense of urgency associated with complex problems, like climate change, that science tries to address. In response to these and related forces, western science has sped up. There is thus a need to slow

down to be able to feel and identify differences in respective timescapes and the necessary rhythms for collaboration. For example, in the EAB project, partners from state and federal institutions saw the EAB insect as just one of several invasives they had to address. Given the specific cultural, economic, and ecological interests with EAB and black ash, these partners had to balance the time dedicated to this issue versus others. As the project evolved, time changed as well. In the early stage of the project, there was a sense that “time was on our side” because the EAB was not yet in Maine. This recognition helps to create a space for group reflection about how Wabanaki peoples have faced and survived threats similar too and also much worse than the EAB many times, which itself brought the past into the present in ways that challenged linear and colonial formations of time.

This dynamic orientation to time is akin to what Mustonen (2014) refers to as endemic time-spaces, understood as “a range of spatial–temporal practices of a specific culture” (p. 120). The FoD became a creative space for practicing cross-cultural approaches to time. One important example of this came in the form of our bi-annual research meeting in June 2018, which we held on rafts with the Penobscot River. The time for this meeting was constituted by the flowing water itself and the season. The river trip started just below the Milford Dam in Old Town, and John Banks, Director of the PN’s Department of Natural Resources and a key leader of the Penobscot River Restoration efforts, welcomed our group and described the important relationship between the River and the tribe. Instead of having a formal agenda and set of presentations as we would typically do in a meeting like this, we allowed the river to carry the boats along. As we identified stopping points along the way, Banks and other partners shared stories and information. At one point, returning alewives took over as storytellers when we stopped at a tributary and followed their silvery flashes as they migrated upriver to spawn.

Time was multiply constituted on this trip. The time for our research meeting, which is usually dominated by a linear and narrow sense of progress, shifted to one shaped by the longer term and more dynamic pace of a river. Following the flashes of fish up the stream, the past, present, and future formed timescapes where we remembered the promise of the restoration effort and the fish flowed towards a different kind of future than they might have otherwise had. Though this was a single trip and instance of shifting research timescapes, the practice of orienting to river time flowed through many other parts of our project and became an important way of feeling endemic timescapes (Mustonen 2014) and reconstituting timescapes for sustainability science (Adam 1998; Bornemann and Strassheim 2019).

Critical praxis for sustainability science in Wabanaki homelands

The above analysis highlights the need for practical strategies to work through tensions in conducting sustainability science in Indigenous homelands. In this section, we identify four critical praxis commitments that have been essential in our work. Critical praxis refers to the commitment to take a problem and purpose-centered approach to envision and navigate towards more just futures (Ono and Sloop 1992). In our work, this has meant (1) centering Wabanaki diplomacy and IRMs to shift dominant colonial power in research; (2) creating iterative dialogue to support relationship building and mutual learning; (3) recognizing the multiplicity of time; (4) and supporting Wabanaki students as leaders and researchers. All of these commitments are interconnected in ways that challenge and transform power associated with science as discourse, naming, and constructions of time.

The first praxis commitment centers Wabanaki diplomacy and IRMS to decenter western science and to reclaim the place of this research as occurring within Wabanaki homelands. Wabanaki diplomacy, a set centuries-old practices reflected in the founding of the Wabanaki Confederacy, a multi-national, multi-tribal decision-making body recorded and documented on Wampum Belts (Speck 1915; Walker 1998), addresses problems by respecting multiple voices and giving processes the time needed to work to a common understanding (Ranco 2016). As Ranco (2016) argues, being intentional about centering Wabanaki diplomacy reminds those involved in research processes of Indigenous inhabitation and how forms of governance have existed in this region for millennia and coevolved with the ecosystems and cultures of this place (p. 25). Orienting to Wabanaki diplomacy as a worldview helped situate our sustainability science approach and address the insufficiency of trying to integrate IRMs into a predominantly western science paradigm. As Nadasdy (1999) argues, “Rather than merely assuming, as many do, that integrating knowledge with science will automatically lead to improved resource management and aboriginal empowerment, we must closely examine the assumptions underpinning this project” (p. 2). This examination occurs through a practice of continual questioning of what it means to create the conditions where Indigenous knowledge and sustainability science to flourish together and highlights the need to center Indigenous worldviews as integral to the research process (Smith 2012). Wabanaki diplomacy names an Indigenous relationship to place and offers a contextually grounded and culturally appropriate orientation to dialogue (Ranco 2016). Centering Wabanaki diplomacy has also meant working with Native scholars and collaborators in key leadership roles, for example as Principal Investigators and/or full partners, and setting up informal

and formal agreements to promote reciprocity throughout the research process (Simonds and Christopher 2013).

In addition to challenging and transforming rhetorical colonial formations of place and knowledge, Wabanaki diplomacy also supports creating early, iterative and ongoing dialogue as our second praxis commitment. Dialogue helps create inclusive spaces for learning, identity formation, and relationship building. Centering dialogue as a relational process of knowledge helps strengthen the commitment to Wabanaki diplomacy as the basis for sustainability science. Importantly, dialogue in this sense is not talk about knowledge to learn across difference but instead ongoing embodied engagements with/in Wabanaki homelands that allows knowledge to emerge and flourish.

The commitment to dialogue also helps challenge dominant power, as tribal collaborators face a cultural dilemma similar to that in natural resource management contexts where “tribes are forced to present themselves within the current structures in a way that is recognizable to non-Indians; on the other hand, tribes must maintain and prove their distinct culture” and where “the resolution of this dilemma requires increasing tolerance among non-tribal governments for tribal models of regulation” (Ranco et al. 2011, p. 229). Taking a dialogic approach allows for a sensing of cross-cultural difference and a way to build capacities for knowledge production that do not conform to western colonial conceptions of what knowledge is and how knowledge is produced. The EAB and FoD projects exhibited the most fully developed commitment to early and iterative dialogues, and these efforts emerged later for the SBSP and Passamaquoddy tribal partners. In the EAB, gathering insights and sharing knowledge early on and across the series of meetings was essential for learning (Costanza et al. 2017). Dialogue allowed collaborators to identify novel research foci, such as the need to understand the extent to which campers across New England perceived the threat of the EAB and strategies for limiting the transport of infested firewood (Daigle et al. 2019). There have been a number of important outcomes from this long-term effort, one of which is how the collaboration built capacity for adaptive policy implementation. Importantly, not all of these dialogues occurred face-to-face. In the later stages of the project, webinars created opportunities for individuals and groups with strong interests to express their concerns and describe anticipated consequences for black ash and basketmaking in Maine if the 2018 quarantines were to be removed. The combination of approaches helped expand the digital space for participation in ways that then supported further knowledge production and policy making for EAB planning and management.

The diversity and adaptability with dialogic processes also shaped how project leaders grappled with the multiplicity of time and cultivated different and Indigenous temporal rhythms. The third praxis commitment thus focuses

on practical, epistemological, and ontological orientations to time. On a practical level, we recognize that when we are working with partners time is valued differently, as some are paid to participate and others are not. The differential valuing of time reinforces hierarchies of expertise and knowledge. In the EAB project, there was a commitment to compensate partners who were self-employed in basket-making or harvesting. In addition to direct compensation, providing food at project meetings becomes another way of valuing people's time, releasing them from other temporal obligations for lunch and dinner prep. This was a consistent commitment across all of the cases and came with the added benefit of creating a unique social space in which people could build relationships.

Grappling with the multiplicity of time means attending to how research processes, such as the development of research questions, mutual learning, interpersonal relationships, and meaningful knowledge products, follow distinct temporal rhythms. The ways in which time shapes knowledge production, an epistemological orientation, had an important influence across all three cases. The EAB project again provides guidance on how to shift the epistemological orientation to time to enable the integration of and movement between multiple timescapes. Developing future scenarios to help inform adaptive planning, and especially for the eventual EAB quarantine that was enacted in 2018, created a space where Indigenous orientations to time and perspectives about futurity were incorporated into the scenarios.

The practical and epistemological orientations feed into and shape the ontologies of time, or the multiple temporalities that shape how we feel as we move between timescapes. One of the most important commitments in addressing the multiplicity of time is to recognize that this multiplicity exists and it matters for our work. When we feel the tension in aligning schedules because some are living by academic calendars and some by seasons, remembering that these tensions have a deeper meaning creates a pause to enable creative approaches, such as letting the flow of a river set the pace.

Commitments to Wabanaki diplomacy, dialogue, and multiple timescapes can also support the meaningful integration of programs to support Indigenous students. The fourth praxis commitment focuses on supporting Wabanaki and Indigenous students as leaders and researchers. The WaYS program is central to this commitment, as this program takes a cultural science approach to helping Wabanaki and Indigenous students gain skills and knowledge in leadership, science, and Native cultures (Carr and Ranco 2017). The WaYS program had a formal connection with the SBSP and the FoD, and strengthening the connection with WaYS became a primary focus for the FoD. To demonstrate what this has meant for student leadership and cultural revitalization, we

include a first-person narrative written by Nolan Altvater describing his experience with the WaYS program:

“The WaYS program has helped me find my voice as a Native American student and researcher at the University of Maine, holistically building my Native identity and improving my life as a college student. It gave me opportunities to connect with a Wabanaki community through a collaborative project with the Penobscot Nation (PN) which focused on Indigenous epistemologies and decolonizing methods in scientific research. As an Indigenous Education and English major, I was specifically interested in how storytelling and visual communication approaches could highlight the in-depth water quality work that the PN's Natural Resource Department was conducting and how visual communication approaches could also be a way of practicing reciprocity in research.

The trips out on the River with Jan Paul and Angie Reed, as well as conducting interviews with elders and Wabanaki tribal members, helped me reconnect with my family, build a relationship with the Penobscot River, identify how colonialism was limiting my own personal growth, and how I could combine my love of education and writing to help shape and reclaim Native identities. By listening to the stories my great-aunt, Carol Dana, who is a Penobscot language master working to preserve Indigenous stories and culture, I began to hear a different story for myself.”

As a related outgrowth, the WaYS program has helped Altvater cultivate his interest in using writing to decolonize pedagogy and for cultural renewal. With Altvater's leadership, our group began working with Carol Dana to name this project *Awihkikéhtaso* which in the Penobscot language means “It is made to write.” This project precipitated many additional writing products, including an online portal that links photographs and videos to water-monitoring stations (Quiring 2020). Altvater expanded this work to develop writing techniques to help Native students write into their Indigenous identities and critically reflect on their experiences at UMaine as a colonial institution and to revitalize a series of writing camps with Indigenous youth. These efforts affirm how writing can bring about change and Brooks' (2008) argument that “the success of the literary endeavor would be evaluated based on its capacity as a carrier or catalyst within a network of relations” (p. 220). In light of how these composition processes are (re)constituting myriad relations, we continue to show up for writing to cultivate more inclusive, decolonial, and just sustainability science.

Conclusion

Our guiding question sought to identify and work through tensions in what it means to conduct sustainability science from/with/in the Penobscot River and Wabanaki homelands. We

asked: what are our responsibilities for listening and orienting to Indigenous knowledge and how, having listened in these ways, do we bring what we learned to our research partnerships and the institutions we inhabit? Our response to this question has been to recognize the ways in which science as a discourse creates tensions through the simultaneous production of knowledge and power and how practices of naming and social-material constructions of time shape and reinforce tensions. We sought to engage these tensions through critical praxis commitments that emerged from our overall orientation towards “learning to learn” (Kuokkanen 2007, p. 97).

How can these commitments connect with and be adapted for the other histories, cultures, and contexts in which sustainability science takes place? For us, Wabanaki diplomacy emerged from homelands of the Penobscot, Passamaquoddy, Maliseet, and Micmac and yet also connects with many Indigenous worldviews and governance systems, especially the commitment to listening, respect, and dialogue. However, care must be taken to learn the histories of a place and Indigenous approaches to governance that trace ancient relations between people and their homelands. Related to this, while writing has a unique and powerful role to play, not all partners in sustainability science will value formal writing outputs. It is, therefore, important to continue to challenge discourses about what counts as formal knowledge in academic institutions and to consider how oral storytelling and other forms of communication are also meaningful and distinct cultural forms of knowledge. Doing so can also help cultivate multiple temporalities within research, where creative knowledge processes help trace the rhythms of research in ways that attune to Indigenous timescapes, such as producing a series of images that document and shape relationships with the Penobscot River (Quiring 2020). Finally, the partnership with the WaYS program has been one of the most important aspects of all of this work and is a model that could be applicable in many other places (carr and Ranco 2017). Centering student leadership, creating a network of support, and helping students flourish are overarching commitments that we see as essential for conducting sustainability science in Indigenous homelands.

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