



Measured impacts of engaging community with floating wetlands and eco-art in Seattle, WA, USA

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Abstract

The Lake Washington Ship Canal in Seattle, Washington has a strong human-dominant history as an industrial landscape. This Sweetgrass Socio-Ecological Study analyzed relationships between people and the environment to understand the role community engagement has in connecting humans to more-than-human elements such as vegetation, water, air, and wildlife. Participatory action research was supported by a landscape biography focusing on the site's environmental history. Design interventions were then used to create awareness of and help address injustices to more-than-human elements in the landscape. Finally, a post-occupancy evaluation was conducted to examine the landscape literacy, ecological literacy, and place attachment of site users. This study demonstrated the importance of a participatory action process that considers both human and more-than-human elements. Post-occupancy evaluation responses indicated that engaged community members considered more-than-human elements and showed a greater desire for proenvironmental behaviors. They highlighted the role community engagement can play in strengthening relationships between humans and more-than-humans. This study suggests that community engagement in landscape restoration interventions is important in cultivating meaningful connections with the land and is necessary to restore system relationships between humans and more-than-humans. It also suggests that expressing narratives—sometimes called “storytelling”—through design and ecorevelatory practices should be more widely implemented for people to understand and steward landscape systems around them. A holistic lens to design is vital to improving the relationships between people and the environment and to promoting landscape stewardship practices.

Keywords Constructed floating wetlands · Participatory action research · Landscape biography · Post-occupancy evaluation · Ecorevelatory design

1 Introduction

Postindustrial, urban shorelines reveal significant histories of intense degradation and modification as part of their human-dominant narratives. Although the Lake Washington Ship Canal was a primary out-migrating passage for juvenile salmon, this anadromous population within Seattle rivers is now in steep decline (Higgins et al. 2020). The aim of the Sweetgrass Living Shorelines and Sweetgrass Eco-Arts

projects were to understand the history of the landscape and create an intervention that drew greater attention to more-than-human elements within the site. Furthermore, it was intended to examine any change in human knowledge about these elements and their connection to the landscape. This action research process examined how the implementation of constructed floating wetlands along with community engagement could be used to improve human relationships to landscape systems.

Salmon are a keystone indicator of ecological health in Pacific Northwest aquatic environments. In the Lake Washington watershed, they begin life in the natal freshwaters of the Sammamish and Cedar Rivers, making their way through the rivers into Lake Washington. The salmon then swim through the Montlake Cut, Lake Union, and the Lake Washington Ship Canal to the Salish Sea. Salmon are also a central cultural icon and economic basis for local Indigenous

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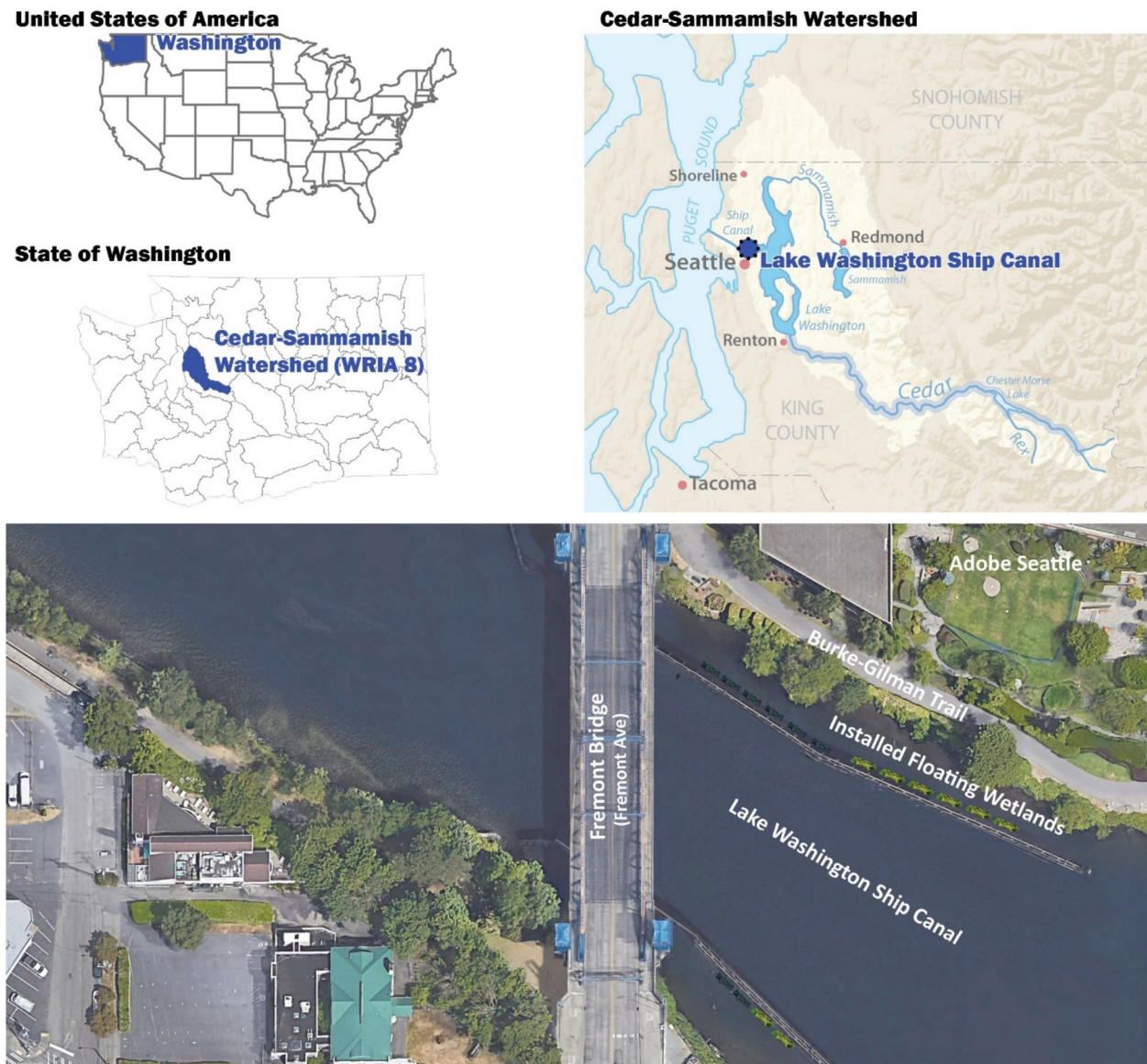


Fig. 1 An aerial view of the project site location (Base maps in upper left and right are from Wikipedia and modified by one of the authors. Bottom map base is from Google Earth and modified by one of the authors.)

tribes (Muckleshoot 2012). See Fig. 1 to understand the location context.

The Sweetgrass Socio-Ecological Study investigated the role that human-created elements added to a landscape system could play in strengthening human understanding and connection to it. New floating wetlands and eco-art were installed in the Lake Washington Ship Canal near the Fremont Bridge and along the adjacent Burke-Gilman Trail in Seattle, Washington, USA. Systems theory supports an approach of conceptualizing and understanding the landscape as a holistic environment for humans and

more-than-humans. Human and more-than-human elements¹ such as vegetation, water, air, and wildlife each have individual and interactive roles within a landscape system. A system is defined by three categories: its elements, interactions, and overall system function (Scheffer 2009). System

¹ More-than-human defined in Oxford Reference as a “term used positively to highlight the dependence of humans on a vast and complex array of non-human entities” (Castree et al. 2013). The positive connotation of the word suggests agency for these system elements instead of being something that is not human. This term also seeks to decenter humans and reconnect humans into the ecosystem (Tran et al. 2024).

complexity can be simplified into these categories, allowing one to concentrate on the dynamics of all elements (Haraway 2016; Marchand et al. 2020; Scheffer 2009; Society for Ecological Restoration International Science and Policy Working Group 2004). This research focuses on the relationships between system elements and how design can modify those relationships. More specifically, how can design and design processes positively affect human perception of a holistic connection to a system and its elements? Landscape ecology, feminist theory, and Indigenous knowledge characterize people as a part of the system and point to the importance of humans not dominating more-than-human elements of the system (Haraway 2016, p 3; Kimmerer 2013b, p 53; Whyte et al. 2018, p 155). For this research, the team sought to understand the historical changes within the landscape, find ways to repair broken connections, and determine the impact of landscape interventions on human understanding of the landscape system. We asked:

1. How can people be educated to comprehend landscape narratives, their connection to the historical system functions and their continuation to improve future systems? (Landscape Literacy)
2. When a design intervention makes more-than-human elements more visible, do people better understand the system's function and the interactions of these elements? (Ecological Literacy)
3. During design, implementation, stewardship, and research, how does community engagement impact one's connections with the site and more-than-human elements? (Place Attachment)

These questions aimed to identify the roles landscape design can play in improving relationships between system elements, particularly how humans relate to more-than-human elements. The process is intended to consider the holistic² landscape from the beginning of a restoration project to its end and understand the impact it has on socio-ecological relationships in the landscape. System interactions are critical in considering a landscape containing both human and more-than-human elements; this research was intended to assess the impact design and design process can have on system relationships and how understanding of the system can influence effective design. The project processes and results of the associated socio-ecological study suggest ways in which community engagement may strengthen human learning and caring for the holistic landscape.

² Holistic thinking and systems refer to the understanding that human and more-than-human elements work together to create an ecosystem that is beneficial for all elements.

1.1 Project components

The Sweetgrass Living Shorelines project took a systems-based approach to determine where new interventions were needed to promote and repair system performance for more-than-human elements. Given that traditional restoration was not feasible for this urban shoreline, constructed floating wetlands were installed to restore salmon habitat in the landscape. Community engagement can expand system interactions and potentially influence perceptions and care for vegetation, water, air, and wildlife. Therefore, project team researchers, designers, community scientists, and students worked together to examine plant health, fish use, and water quality parameters to determine whether the constructed floating wetlands could provide sufficient and suitable habitat for salmon. This intervention connected communities by providing education on system dynamics focused on conditions needed by more-than-human elements. The Sweetgrass Eco-Arts Project research team invited local artists to create banners, stencils, signs, and poems to inform the public about the floating wetlands. This allowed artists to share their own water-land connection stories. Sweetgrass Arts promoted these connections by encouraging a knowledgeable relationship between humans and more-than-human elements through interpretive art elements and activities.

1.2 Foundational theory

One strategy to enhance system relationships is to create awareness of system dynamics through community engagement. Educating and engaging individuals about elements within the system enhances their awareness of surroundings and roles. The European approach to landscape ecology considers how people are a part of the landscape and engages the community with human and more-than-human elements (Higgs 2003, p 76). Community science deepens one's sense of place attachment (Toomey et al. 2020, p 1) which is derived from people's connection to the full ecosystem and the "emotional bond" between humans and place along with healthier interactions between ecosystem elements (Manzo and Devine-Wright 2012, p 1). Place implies a "safe and familiar" feeling and personal relationship people have in an environment (Tuan 2013, p 6).

Recognizing interactions between elements can create a connection to place for humans. One form of place attachment through a feminist lens is the application of a care ethic to a place (Noddings 2012, p 1). Indigenous scholars have written about place attachment as a mutualistic community and have shown care for more-than-human elements through storytelling and human relationships with the land (Whyte et al. 2018). This thinking seeks to consider more-than-human elements and their relationships in the system while minimizing human impact that hurts other elements

(Kollmuss and Agyeman 2002, p 253). Such holistic understanding of places may facilitate proenvironmental behavior. The Sweetgrass Socio-Ecological Study examined general site users' and community scientists' connections with the Fremont Sweetgrass project site and assessed how they subsequently demonstrated care and proenvironmental behaviors toward this landscape.

This research also explored how storytelling through design (Heatherington 2011, p 171; Potteiger and Purinton 1998, p 5), ecorevelatory design (Helphand and Melnick 1998, p x; Wenk and Gregg 1998, p 24), and community engagement can influence landscape literacy (Spirn 2017), ecological literacy (Boehnert 2012; Orr 1992), and place attachment (Manzo and Devine-Wright 2019, p 3). Specifically, the project considered the impact of a design intervention on human and more-than-human relationships when working to foster holistic thinking. While the project is place-based in Seattle, it demonstrates a process for research that involves community members that could occur globally to encourage integration of humans and more-than-humans within an ecosystem.

1.3 Community engagement

Community engagement³ refers to a component of community design methodology that was first introduced by Randy Hester (1974). Hester's methodology centers on a community's role in deciding what should be designed in a space (Hester 1974, p 53–54). The Centers for Disease Control and Prevention (CDC) has defined community engagement as “the process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people” (CDC 2011). The CDC defines community in terms of systems and social, virtual, and individual perspectives. When considering a community in terms of systems, the goal is for people to come together to consider the problem “in relation to the whole organism” and to understand the sector collaboration necessary for a healthy system (CDC 2011). Social perspectives seek to find behaviors and patterns that link people together and form a greater depth of community (CDC 2011). In design, community engagement enhances a project by bringing together people of different backgrounds, knowledge, and ideas to

determine strategies for future design interventions. This can be done in creative ways that allow for diversity of voices and a variety of impacts on the system (de la Peña et al. 2017). When people collaborate during design, construction, research, and outreach, the process allows for equity and environmental justice to lead the design intervention (Andrews et al. 2022, p 11).

When considering community engagement and its impact on a larger ecosystem, systems-based thinking can expand relationships to span from human to more-than-human. While landscape systems usually include such interactions, they often do not consider holistic relationships. Instead, designed interactions primarily center on how human elements benefit. Within an inclusive approach to design, relationships between all elements become essential. Indigenous planning has long focused on relationships that benefit the entire system (Whyte et al. 2018, p 152). In many Indigenous planning practices, design principles focus on developing relationships, trust, and respect. These approaches are based on experiences with the land and the understanding of relationships fostered in those settings. The intent is not to define specific design techniques or elements for a given site but to engage in approaches that actively listen to the land, live in community, and then respond. The approach is grounded in relationship building and collective interpretation, not system element modifications. Systems-based design aims to be inclusive and can be paired with Indigenous planning, particularly in terms of focusing on community relationships, rather than on a specific function or performance.

Prior knowledge informs current and future practices of community engagement and relationship building. Community engagement is often combined with storytelling through design and ecorevelatory design to identify interactions and relationships and how they have changed within the system. Responding to Eisenstein's (2001) criticism of ecorevelatory design, the system and function cannot change without a modification in interactions and human relationships to other elements in the system. If we consider design as the change in interactions and function of a landscape, human engagement within the process is crucial to change the system's relationships. Restoration ecologist Eric Higgs explains that “community engagement and local culture” may change system elements (Higgs 2003, p 4). He elaborates that humans connect with more-than-human elements and the system more effectively “when they get their hands dirty, literally, and the lessons learned hold fast” (Higgs 2003, p 4).

Within these complex relationships and system dynamics, humans inherently try to “control” interactions and outcomes. Even when we want to create “wildness” in design, we desire a specific aesthetic. Higgs reminds us that wildness cannot be predicted and that “one must engage in reciprocal relationships, giving as much as one takes, listening as much as talking” (Higgs 2003, p 58).

³ Often, work like this could be called citizen science (von Gönner et al 2023). By using the term “community” instead of “citizen” in the work of community scientists, the audience that is a part of the engagement is not restricted to US citizens or making people feel like they don't belong (Andrews et al. 2022). This study was consistent in that terminology and meaning in considering how communities were involved in the process of design, construction, implementation, and monitoring.

Indigenous culture reminds us of this reciprocal relationship between plants in the three sisters' plantings where they grew corn, beans, and squash together for their mutual benefit (Kimmerer 2013a, p 128; Kimmerer 2013b, p 60). In systems-based design thinking, we can try to provide a framework for interactions and encourage relationships, but we cannot control that process. One must pause and listen to be part of this relationship. The time required to understand system relationships is not built into a typical Western design approach, since it does not frequently include advocacy for a holistic community and its relationship culture. Therefore, this project began with an understanding of human and more-than-human historical relationships through a landscape biography to determine what interventions were needed in repairing broken relationships. This changes the focus from a human-dominant Western design approach to one that recognizes past scars and uses a holistic approach that is inclusive of more-than-human relationships.

2 Methodology

The Sweetgrass Socio-Ecological Study used action research to determine if a community engagement in a design intervention would foster a more holistic human understanding of the landscape, advance care and repair damaged relationships between human and more-than-human species in a system.

Participatory action research is defined as “an approach to research that prioritizes the value of experiential knowledge for tackling problems caused by unequal and harmful social systems, and for envisioning and implementing alternatives” (Cornish et al. 2023, p 1). This approach was based on development of a landscape biography to understand the history and harm caused by humans in the Lake Washington watershed. In this action research, the design intervention also became an experiment to test if community engagement in the design could change the relationship between humans and more-than-humans. By being intentional about storytelling through design, ecorevelatory design, and community engagement in the design, research, and intervention processes, the research team was able to assess affected human relationships utilizing a post-occupancy evaluation that focused on human connections and relationships within the system.

This research used the Lake Washington Ship Canal between the Aurora and Fremont Bridges in Seattle, WA as a place to understand the history of the site and system, install and research a design intervention, and conduct a post-occupancy evaluation on human perceptions and attitudes. See Fig. 1 for context.

2.1 Landscape biography

Landscape biographies explore the change in a landscape from past to present and into the future (Kolen et al. 2017, p 120). Like a traditional biography, a landscape biography tells a story about the ecosystem using historic images, reference documents, and interviews to understand system dynamics and necessary design interventions. The landscape biography creates a foundation for participatory action research to holistically understand the landscape system and determine where design interventions should occur. This provides evidence for the role more-than-humans play in the landscape. The landscape biography that underpinned this project explored the human and more-than-human changes within the landscape to understand changes in the ecosystem dynamic over time. Without understanding past relationships, effective restoration cannot be accomplished or relationships repaired.

The Waterlines Map from the Burke Museum (Sheikh et al. 2019) documents the past water-related landscapes of present-day Seattle, illustrating the original water connections, Indigenous heritage, and importance of water for this landscape. Additionally, the Museum of History and Industry's online archive of historic images were culled for images of the present-day Lake Washington Ship Canal. Images were found between 1904 and 1991 showing the evolution of the Ship Canal that significantly altered the watershed flows and riverine ecosystems in the area. Interviews with community members demonstrated the role people played and are currently playing in the relationships with more-than-human elements of the landscape. Once a timeline was created, the shift in landscape characteristics was considered from a variety of perspectives including vegetation, river/water quality, fish, transportation, bridge, industrialization, and humans. These elements' impacts on the site were traced through maps, images, and conversations to determine how prevalent they are in the landscape, including when major changes were made between the elements, when elements appeared or disappeared, and how prominent elements were interacting with other elements. The landscape biography included more-than-human elements and focused on how their relationships with humans evolved.

This landscape was once a small tributary that flowed from present-day Lake Union to the Salish Sea. It was home to salmon and local vegetation. In 1917, The Lake Washington Ship Canal and Montlake Cut opened as a major industrial passage from the Salish Sea to Lake Washington. This changed the out-migrating juvenile salmon route from the Sammamish and Cedar Rivers to a route through the Lake Washington Ship Canal. As industrialization continued, vegetation declined and water temperatures increased while dissolved oxygen levels decreased. People became the dominant element in this landscape and more-than-human

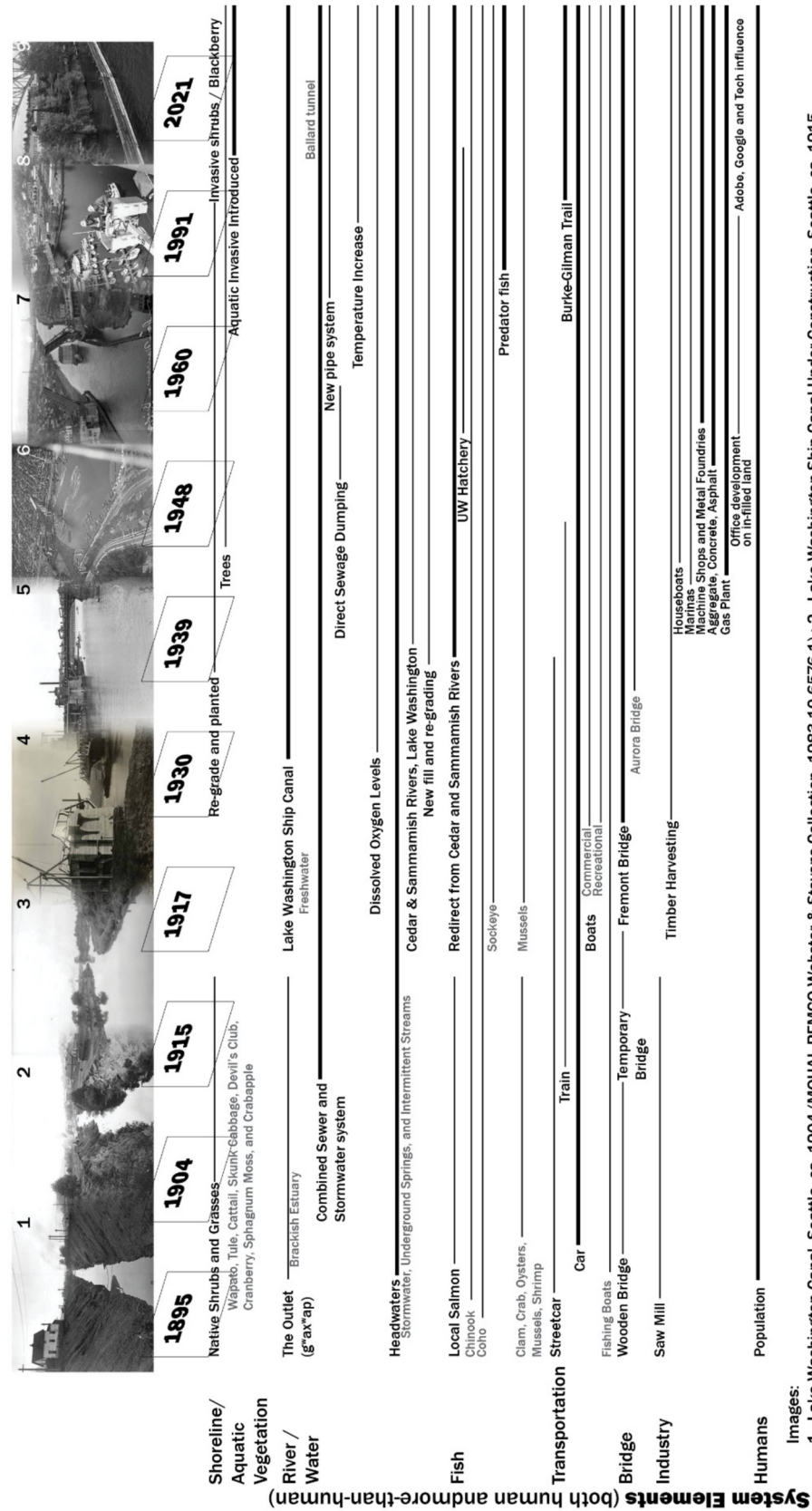


Fig. 2 A timeline of the landscape socio-ecological history of the Fremont bridge area (Graph created by one of the authors. Above images are from Museum of History and Industry in Seattle with paid permissions.)

elements suffered. The change in the ecosystem structure is documented in Fig. 2.

As relationships shifted in the ecosystem, salmon populations significantly diminished (Kerwin 2001, p 12). Until 1991, annual sockeye salmon counts were above 100,000 per year. Numbers have continued to decline since then with only 15 years being near 100,000 and 2019 being the lowest with 18,625 sockeye salmon (Washington Department of Fish and Wildlife 2023). In addition to loss of habitat, temperature levels in the Lake Washington Ship Canal rose significantly and dissolved oxygen levels dropped to lethal limits at certain times of the year (Urgenson et al. 2021, p 21). Relationships between critical elements in the ecosystem have changed considerably over the past 200 years. There has been a loss of caring communities that once defended retaining more-than-human elements along the shoreline.

2.2 Design interventions

The design interventions, Sweetgrass Living Shorelines and Sweetgrass Arts, demonstrate how a site can be transformed to benefit more-than-human elements and change human perception using storytelling through design to facilitate landscape literacy, ecorevelatory design to enable ecological literacy, and community engagement to improve place attachment. The floating wetland design interventions were developed from analysis of the landscape biography, by understanding where the damages occurred, and by finding ways to repair human relationships with compromised elements.

The design, production and installation work was completed using a safe-to-fail methodology (Rottle et al 2022; Ahern 2011, p 341). As the intervention progressed, design changes occurred simultaneously with ecosystem changes. Repairs were made to further support more-than-human elements and increase potential for interactions and understanding of the ecosystem elements. Post-occupancy evaluation methods then allowed the team to review the interventions' impacts on human perceptions from both community-invested and a site user perspectives.

2.2.1 Sweetgrass eco-arts to showcase landscape literacy

Storytelling through design focused on using the landscape design to tell past narratives that have been buried (Heatherington 2011, p 171). Following a design competition, the Sweetgrass Arts team commissioned five local artists from Fremont Arts Council, yáhaó Indigenous Creative Collective, and the Seattle Artist Community who knew the salmon and ecological history of the site. The artists each created banners, stencils, music, or poetry that told their stories of the landscape (Figs. 3 and 4). The artwork showcased salmon, water quality, vegetation, people, industrialization, and development trends. Stencils were developed and used by community members to paint swimming fish on the adjacent Burke-Gilman trail. Colorful banners with the artists' designs were printed and installed along the fender wall where the floating wetlands were moored to encourage people to notice them from a distance. Interpretive signage was installed along the shoreline to help trail users better

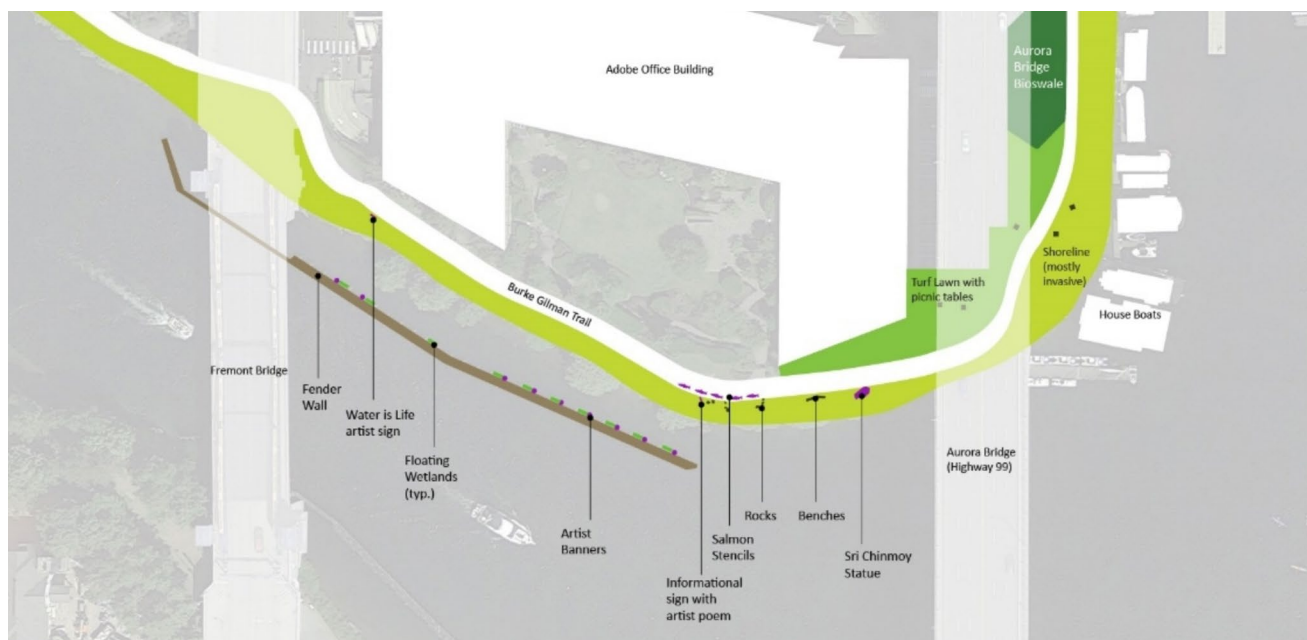


Fig. 3 Site plan showing storytelling and ecorevelatory design elements (Image created by one of the authors with google earth base.)



Fig. 4 Eco-art features from Sweetgrass Arts (Photos by one of the authors.)

understand the wetlands' intended function. Poems were read and songs were sung at a community gathering celebrating more-than-human elements within the landscape system. See locations of art in Fig. 3.

This process of storytelling through design was meant to expose historical narratives on the site and to blend them with present-day narratives and human experiences (Heatherington 2011, p 172). Storytelling through design can enhance human understanding of site elements, interactions, and relationships. Design elements might include art, relics, and materials intentionally incorporated to remind site users of past and present stories (Anholt and Mavor 2013; Heatherington 2011, p 175; Hood and TED Talks 2018). The landscape can be “read” from these elements to establish narratives about human, more-than-human, and land relationships (Heatherington 2011, p 171).

The goal of the art elements was to help people understand system relationships and function. Two artists created graphic design elements—fish in the water, salmon gills patterns, and marsh grass geometrics—that told a salmon story. These design elements were added to the banners hung next to the floating wetlands, with words added to remind people of more-than-human elements in the system (see Fig. 4a). Another artist designed a stencil that was used to paint salmon on a local trail to connect

people to the channel that ran parallel to the trail (see Fig. 4d). One Indigenous artist created a sign sharing her relationship with the land and water. Her work demonstrated “Water is Life,” an Indigenous phrase that became popular to a larger population during pipeline protests. She explained that the inspiration for her work came from “living off the land with my family” (see Fig. 4b). Lastly, an informational sign featured poetry from an Indigenous artist. This poem shares a holistic perspective on the land and relationships between system elements. The poem was presented on an interpretive poster that explained the constructed floating wetlands (CFWs), the history of the area, and the goals of the research project (see Figs. 4c and 5). The art and education elements told the story of the landscape system and supported people in sharing their perspectives of the land and project.

These art elements served as temporary strategies to engage the community in design interventions and offer opportunities for people to consider the landscape system. In the Sweetgrass Arts project, design through storytelling goals included conveying the story of salmon through the landscape and allowing artists and Indigenous people to share their perceptions—what they called stories—about the land.

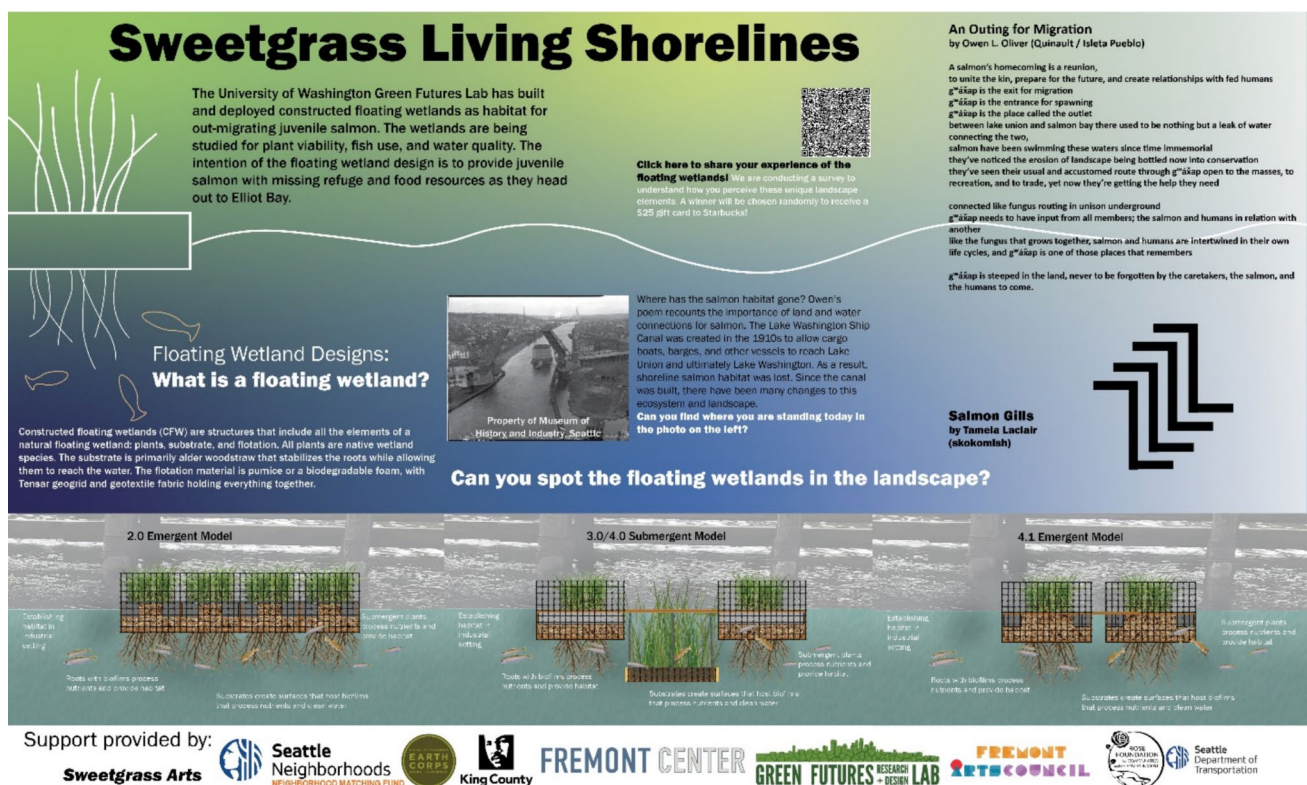


Fig. 5 Signage that was displayed along the Burke–Gilman trail to help explain floating wetlands, share the site history from multiple perspectives, and communicate the research goals (Graphic by an author.)

2.2.2 Sweetgrass living shorelines and ecorevelatory design to facilitate ecological literacy

Ecorevelatory design focused on promoting more-than-human elements and repairing damage humans have done in the past to aquatic habitat and related ecological concerns. The Sweetgrass research team recognized the need for salmon habitat to be recreated in this system to benefit out-migrating juvenile salmon. The team took lessons learned from their prior Duwamish Floating Wetlands design (Rottle et al. 2022, p 8) and implemented CFWs on the shoreline of the in-water shore-protective walls adjacent the Fremont Bridge. The aim was to locate them in a place that did not have existing habitat. Historically, salmon had been observed congregating in Lake Union for one to two days or up to two weeks before swimming through the Lake Washington Ship Canal (Urgenson et al. 2021, p 40). By situating CFWs at the edge of Lake Union and the Lake Washington Ship Canal entrance, the wetlands increased habitat space for salmon to feed and rest while out-migrating. See Fig. 1 to understand the CFW location. Since salmon migration routes have drastically changed over the past 125 years, floating wetlands were intended to provide a design intervention to change the system's dynamics and to extend benefits to more-than-human elements.

This project tested three design prototypes to ascertain whether selected plants would grow and provide salmon habitat space. Each emergent prototype had material for flotation, substrate, plants, and cohesion. These units, shown

in Fig. 6, were tested and constructed with support from a King County Waterworks grant and a Rose Foundation/Puget Soundkeepers grant. CFW units were installed at the Fremont Bridge protection walls in June 2021. See Fig. 7. They were monitored during the 2021 and 2022 growing seasons for plant health, water quality, and fish use. The prototype installation was designed to benefit more-than-human elements by growing native plants that provided food sources and shelter for out-migrating juvenile salmon, and to demonstrate these potential solutions by locating them in a publicly visible location.

Ecorevelatory design was developed to make more-than-human elements more visible and intentional in the landscape design instead of suppressing them (Helphand and Melnick 1998, p ix). In the early 1990s, this design approach began to be used to raise visibility in stormwater management and promote green infrastructure (Wenk and Gregg 1998, p 24). When weaving ecorevelatory work with systems theory, design reveals more-than-human elements and their relationships and interactions within the system. From this design methodology, humans can experience heightened awareness of more-than-human elements, thereby increasing ecological literacy by seeing and interacting with these elements more frequently.

In the Sweetgrass project, CFWs were the “revealing” element that exposed and regeneratively interacted with the system. They were installed to cultivate a connection between human and more-than-human elements within the terrestrial and aquatic landscape through their visible



Fig. 6 Floating wetland prototypes tested by the project (Images created by an author)



Fig. 7 Installed floating wetlands. Henderson’s checkermallow (l), sweetgrass and slough sedge (m), and tufted hair grass (r) growing in the 3.0, 4.1, and 2.0 units (Pictures taken by one of the authors.)

presence. The CFWs near the Fremont bridge answered the need for vegetation, food, and shelter for out-migrating juvenile salmon and other more-than-human elements. Taking this ecorevelatory approach was intended to bring attention to salmon and demonstrate possible solutions to help their survival.

2.2.3 Community engagement to promote place attachment

System function relies on positive relationships between elements. Intentional community engagement during restoration processes can help people to understand the goals behind holistic system design and recognize how it might benefit more-than-human elements. Such engagement is a means by which humans can show care for the system and consider their roles in a large system (Haraway 2016, p 4). Indigenous peoples value mutualistic relationships in systems (Whyte et al. 2018, p 166). The project aim was to test if community engagement could build such relationships using CFWs in an urban setting.

In the Sweetgrass project, community engagement occurred during planning, design, construction, implementation, monitoring, interpretation, and celebration of the intervention. During the planning stage it was critical to include local professionals who have careers built on salmon and aquatic ecosystem research, those involved in the Seattle permitting process, and major water partners within the region. The goal was to strengthen the grounded research using existing knowledge. Meetings and workshops were used to gather existing wisdom, propose solutions, and undertake required processes to design and install the CFWs. Participants were invited by research team members.

Initially, an Urban Shores Working Group, a form of community engagement, supported and advised the university-based team working to reveal systems and connect elements through the CFWs. This group consisted of 20–30 professional designers, ecologists, and scientists with in-depth knowledge of salmon migration and implementation of floating wetlands in the Seattle area. After a preferred location for floating wetland installation was selected, the university-based design implementation team invited assistance from a local nonprofit, Indigenous stewards, local authorities, volunteers, and university students to build and install responsive design interventions. Additionally, 33 community members participated in the project from implementation through its monitoring phases. This project compensated 27 individuals for their time and work. Two community members volunteered time and materials to help install the prototypes. One was a representative of a local authority that helped with the installation. The research monitoring team included University of Washington Green Futures Lab staff along with community scientists. Five artists engaged in

the Sweetgrass Arts project were also compensated for their work. Two community members were engaged to collect data and monitor the floating wetlands. Each week during the monitoring season one community member accompanied a research member to take samples of plant height, percent cover, and EXO2 sonde water quality collections. Community members shared their experiences with local surface waters while the research team trained them in construction and monitoring methods. All helped with the repair and maintenance of the units.

To stimulate broader community participation, a field trip and an eco-arts event were held to further disseminate information about system relationships and to engage students and artists in the project. The research team and Indigenous stewards led a field trip to teach middle and high school students about floating wetlands. They toured natural floating wetlands, saw where the CFWs were constructed, and visited the installed CFWs by boat. The day-long eco-arts community event had booths set up for people to learn about CFWs and install stencil artwork along the Burke–Gilman trail adjacent to the Fremont CFWs. The event, funded by the City of Seattle Neighborhood Matching Funds Program, included food, a local deejay, and poetry performances by one of the project artists. The Sweetgrass Research Team was joined by two other organizations working on floating wetlands and salmon-related work in the area. Since the stencils did not adhere well to wet pavement that day, an undergraduate class painted more stencils during a later site visit where they learned about the project and landscape.

The community engagement goals were threefold: first, to create opportunities for people to be involved with the project, interact with other teams, and install and monitor an intervention that helps more-than-human elements; second, to allow people to share their own narratives and knowledge about the space; and third, to educate others about the role floating wetlands play in the ecosystem and how they can support more-than-human elements. By engaging community members throughout the project, this action research was able to examine the project processes' impact on participants' landscape literacy, ecological literacy, and place attachment. The research especially sought to understand if community engagement might positively affect human relationships with the ecological system.

2.3 Post-occupancy evaluation

New system relationships between human and more-than-human elements, and how they related to the ecological and storytelling interventions, were examined through intercept surveys and site observations (Creswell 2009, p 146; RMS Blog Staff 2021; Robson 2002). These methods measured landscape literacy of site narratives, ecological literacy of more-than-human elements, and people's place attachment

to the site. An anonymous survey was distributed to the public at a community event, canvassed by a researcher, and accessed through a QR code or hard copy that was returned to the researcher immediately. Research questions are found in Appendix B. To examine if people understand the site narratives, they were asked, “What art features have you noticed on the site? Do they tell you anything about the site?” This looked to identify if people recognized the elements that were intentionally implemented to help tell the story of the landscape. Additionally, people were asked, “Is there a certain art or landscape element that helped you better understand the landscape or ecosystem?” To measure ecological literacy, people were asked, “What features may be contributing to a healthy ecosystem?” and “How would you explain the floating wetlands to your friends?” These questions were intended to test how much people knew about the more-than-human elements of the landscape. Lastly, place attachment was measured through the questions “What memories will you take from this place?” and “Would you be interested in being a steward to help care for the landscape? If so, why?”. These questions assessed if people felt connected to the landscape system through both feelings and actions.

Forty (40) survey responses were collected from public “site users”, and eleven (11) from the more deeply “engaged community” members who were involved in the community engagement described in 2.2. All respondents were over 18 years of age and voluntarily chose to participate in the study. Notably, 25 of the respondents participated in the survey after the main interpretive sign was vandalized or removed from the site. However, other design elements such as the floating wetlands and educational banners remained intact. Distributing physical copies of the survey generated the most results; few responses came from handing out QR codes or leaving the QR code on the sign. Survey responses were manually coded for common responses and key ideas that were intentional goals of the design team (Creswell 2009, p 146). For site observations, the researcher spent an average of 54 min on the site at four different times throughout the week to understand how people walked, ran, or biked throughout the space (Gehl 2022; Gehl and Svarre 2013, p 21). They tracked whether people noticed or stopped to view the floating wetlands, art, or signage. The focus of people looking at human elements was compared to attention paid to more-than-human elements in the landscape.

3 Post-occupancy survey and site observation results

3.1 Landscape literacy

Design through storytelling was implemented to develop landscape literacy among site users. Landscape literacy

occurs when site users can read and understand the “environmental, social, economic, and political stories embedded in their local landscape” (Spirn 2019, p 2). The design interventions of the Sweetgrass Arts project incorporated elements intended for people to “read” the landscape and system.

Through the public survey, landscape literacy was measured by what people saw in the space and how they understood the design story. When prompted about what art features they had noticed on site, 15% of the 41 general site user respondents noticed the salmon stencil, 10% mentioned the banners, and 53% mentioned an unrelated statue (see Fig. 8). These responses indicate that without prompts of what the elements are, people could identify some element of art in the landscape. However, multiple respondents did not consider the Sweetgrass Arts banners, signs, or stencils and often asked, “What is art?”.

Among the art features added through Sweetgrass Arts, there were two signs posted: one by an Artist depicting “Water is Life” (Fig. 4b) and the other explaining the project, history of the site, including a poem by one of the artists (Figs. 4c and 5). The latter sign was vandalized and consequently removed for part of the survey time.⁴ Overall, the signs were noted by 32% of 41 general site user respondents, but when both signs were up, the sign was mentioned 47% of the time ($n = 15$), as shown in Fig. 8. When the sign was present, there was increased attention to the art elements explaining the system and project. Without the sign, people focused more on nearby statues or graffiti. When asked what art or landscape element(s) told them most about the land, 25% of 51 overall respondents mentioned the signage. Once again, when both signs were up, 40% of 15 site users mentioned the signage as an element explaining site narratives. These temporary art features communicated the most detailed information about the landscape. Despite a low survey response rate, those who responded expressed an interest in learning the larger ecosystem story.

People walking along the Burke–Gilman trail had varied levels of interest in the art elements and landscape design. From site observation results, 38% of walkers noticed the sign or salmon stenciling while only 4% stopped to read the sign and poetry. This stretch of the Burke–Gilman trail also has a Sri Chinmoy statue and two waterfront benches. Twenty percent of people stopped at the statue or the benches. While people glanced over and noticed the floating wetlands, very few stopped, which could be explained by people seeing the wetland units but recognizing that they

⁴ This sign was removed by someone outside of the research team. The sign was initially removed soon after installation. It was replaced right away and stayed up longer the second time. Unfortunately, it was slashed again and removed before the research team could repair it.

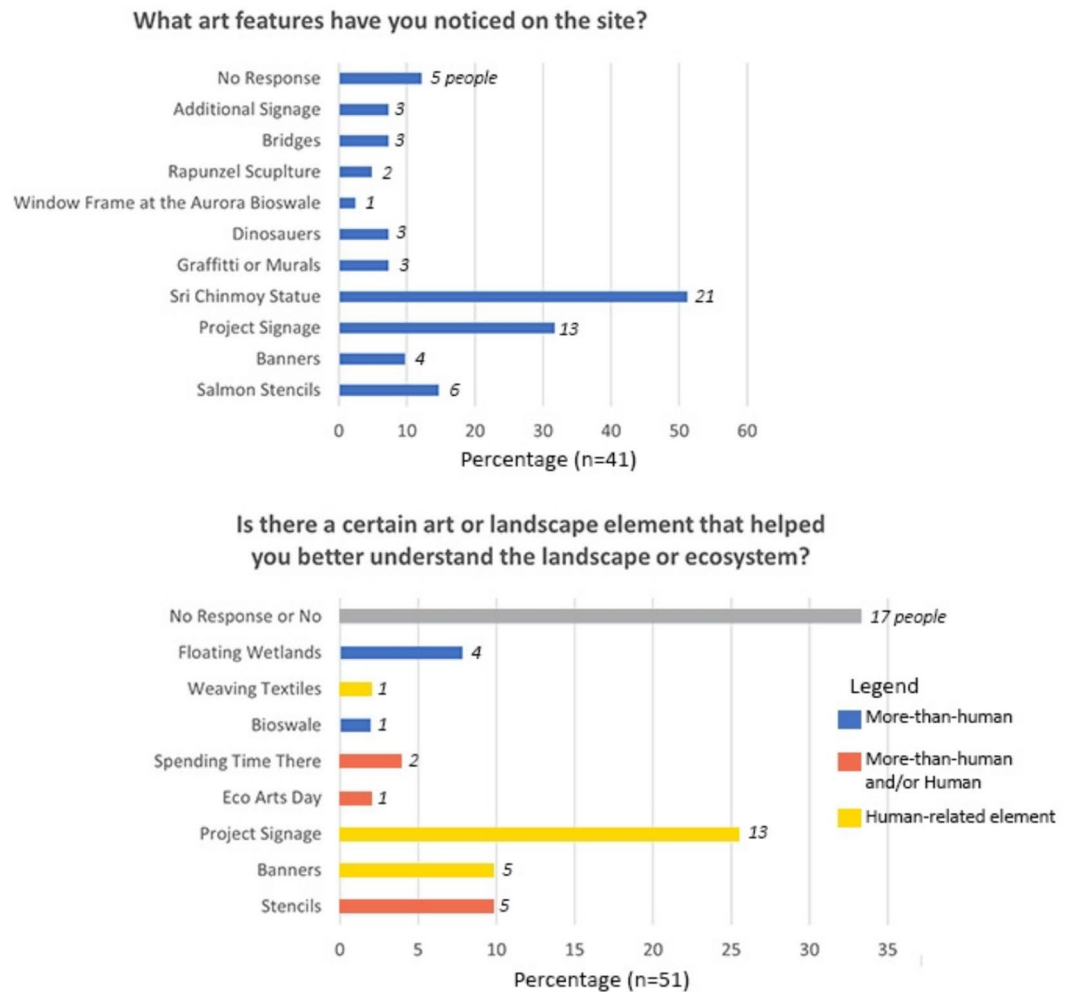


Fig.8 Survey results that related to landscape literacy of all site users (Graphics by an author)

could neither approach nor physically interact with them. A higher percentage of people paused at the more permanent elements, such as the statue, which may indicate that permanent design characteristics have a stronger presence and significance in the landscape story than do temporary elements. This is a landscape that people often travel through. Stops people make are often for resting and views. If people come on a routine basis, this may be a habit they have developed, and temporary installations do not allow for that habit to be built. It was interesting to observe children passing through the site and pointing out the painted fish. They were curiously noticing what was around them and sharing that with the adults who may or may not have otherwise taken note. Designed storytelling elements need to tell the system story more permanently and vividly. They should draw people into the space rather than just explain it off to the side. Views of the floating wetlands were obscured by growing invasive vegetation along much of the trail, which could have further hampered users' perceptions of the wetlands and banners.

3.2 Ecological literacy

Ecological literacy encourages an understanding of systems and landscapes, specifically more-than-human elements. The term was initially used to define elements important in environmental education and what is learned by exploring the land (Orr 1992, p 86). However, since its initial conception, experiential environmental learning has focused on human knowledge gained through the understanding of more-than-human elements of a system (Boehnert 2012, p 35).

In this study, ecological literacy was measured by site observance and user survey results to determine whether people had noticed and understood more-than-human elements on the site. For example, when observing people on the site, 38% of 184 walkers stopped near and observed the floating wetlands or lake channel where they could be seen from the trail. This is the first indication that people noticed something other than humans in the system and stopped to observe what was happening around them.

In the survey, site users were asked to define floating wetlands in their own words. 48% of 41 general site user respondents attempted to define floating wetlands; respondents noted salmon (24%), plants (17%), and habitat (25%), which included food, bugs, invertebrates, and shelter, as shown in Fig. 9. When asked about what features contributed to healthy ecosystems in the area, 11% of respondents mentioned the floating wetlands. While the floating wetlands were designed to support and reveal more-than-human elements, 47% appeared to recognize these narratives on the site through the CFWs and art elements.

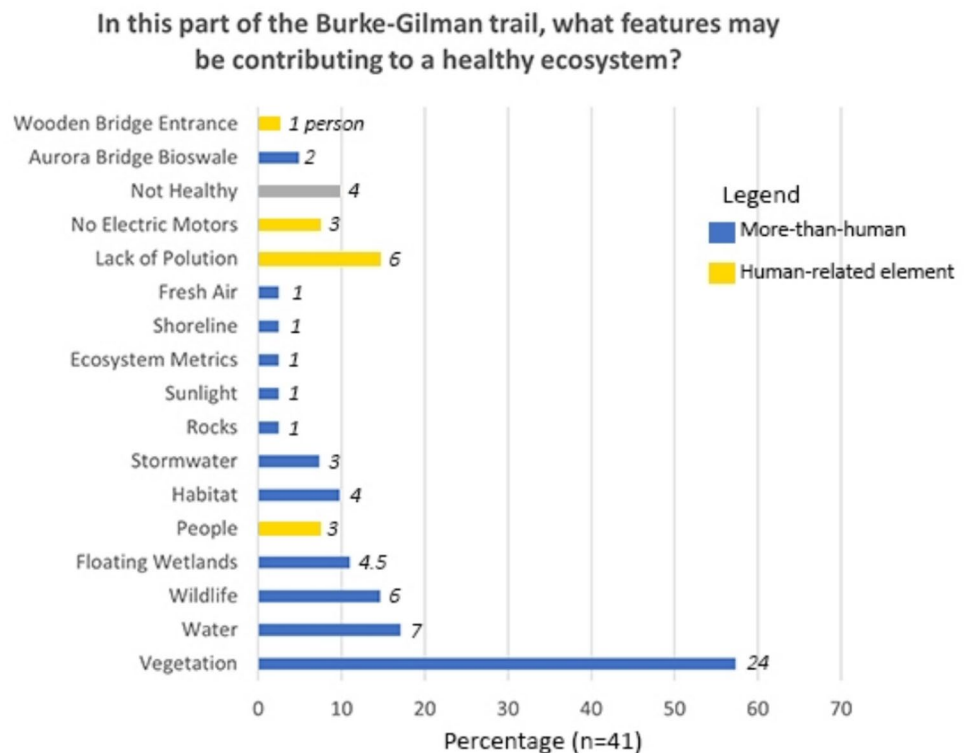
3.3 Place attachment

Community engagement in a landscape can help form a place attachment to the system (Toomey et al. 2020, p 1). People establish attachment to a landscape by showing care and respect to more-than-human elements through proenvironmental behavior (Kollmuss and Agyeman 2002, p 253). Humans have relationships and interactions with more-than-human elements in a holistic community and demonstrate care when interacting positively with more-than-human elements. Place attachment can be displayed by memories people share about a place (Cooper Marcus 1992, p 88), their desire to help better the place (Kollmuss and Agyeman 2002, p 250), and their desire to connect with the land (Manzo and Devine-Wright 2012, p 15).

General site users' (i.e., public) and engaged community members' (i.e., steward, research, and design team participants) ($n = 51$) responses to the surveys showed their place attachment to the site based on the memories of the site, what they learned, and whether they were interested in helping steward the landscape (Fig. 10). General site users ($n = 40$) reported more limited memories of more-than-human elements with their greatest recall related to social interaction and human elements (42%). In contrast, engaged community ($n = 11$) reported that social interaction and human memories contributed at the highest level (73%), acknowledging that they were influenced by memories of habitat or ecosystem (55%) and education, stewardship, or proenvironmental behavior (46%). These findings indicate that while human interaction was important, engaged community members linked that interaction to more-than-human elements of the system. In learning about floating wetlands, 48% of the general site users came to think differently about the landscape compared to 100% of the engaged community participants. Of those who responded that they thought differently about the place, 60% overall noted something educational they learned that changed their perspective. Engaged community members overwhelmingly demonstrated greater knowledge and stewardship of more-than-human elements than general site users.

The survey also asked whether people were interested in being stewards. By expressing interest in becoming a steward, people are showing a desire to participate in the

Fig. 9 Survey results that related to ecological literacy of all site users (Graphics by an author.)



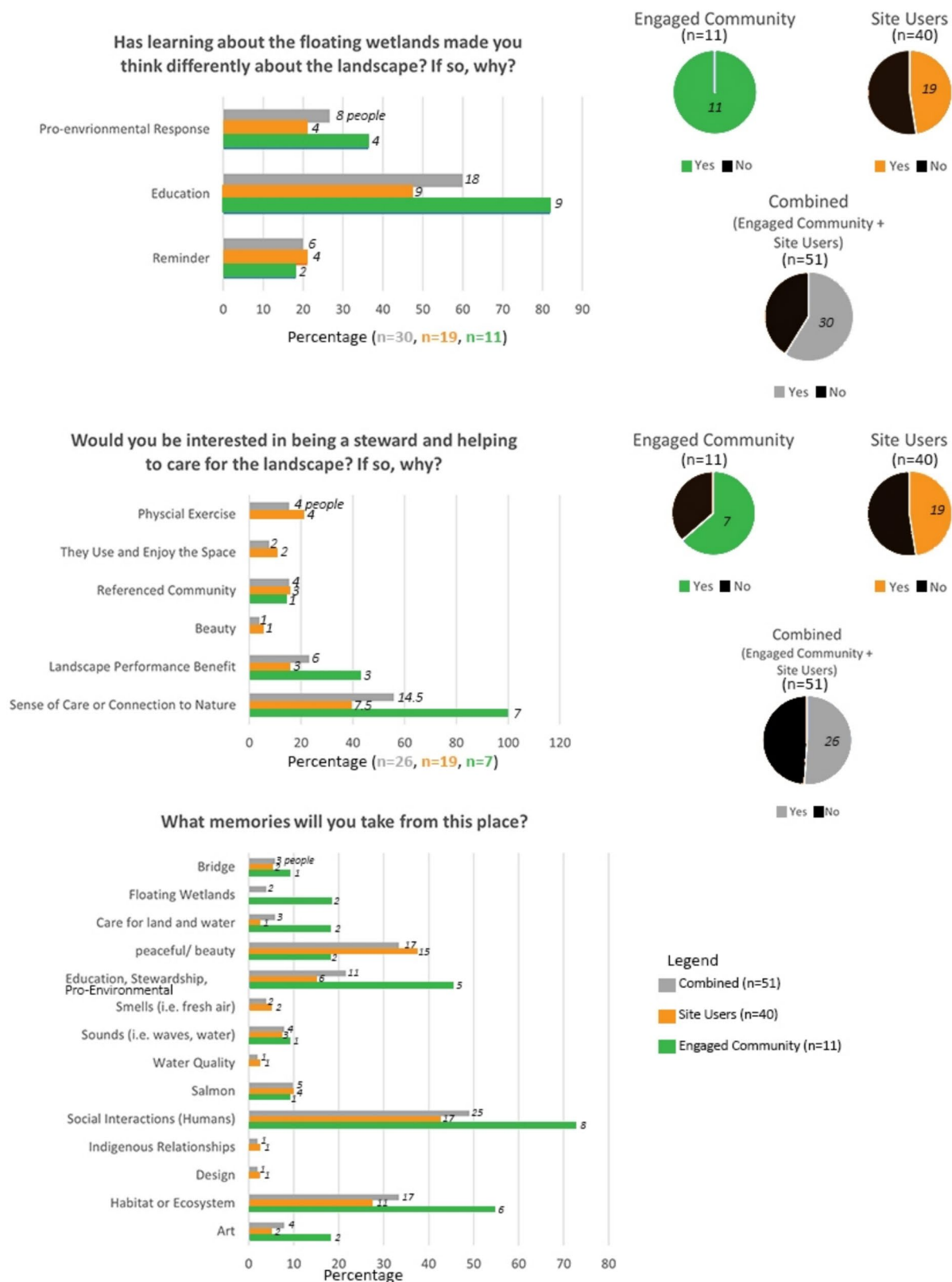


Fig. 10 Survey results related to the place attachment of general site users and the engaged community (Graphics by an author)

system and care for more-than-human elements. Overall, 51% of the 51 respondents were interested. Those who were not interested often stated that time was an issue. For those who responded “yes,” 56% ($n = 26$), including 100% of the engaged community respondents, felt connected to nature or mentioned caring for the land. Twenty three percent of the responses mentioned wanting to benefit the overall landscape performance.

People demonstrating a desire to care for the landscape and to be active participants in helping human and more-than-human elements of the landscape may signal human attachment for the place and a desire to continue to improve system relationships. Place attachment is often strengthened by human understanding of landscape and ecological literacy of the site.

4 Discussion

4.1 Reflection of role of community engagement and place attachment

Community engagement is an inclusive way to involve diverse stakeholders in the design and science process (Campbell-Arvai and Lindquist 2021). Hester’s work and many of the case studies for Design as Democracy (de la Peña et al. 2017) focus on community feedback that is woven into final design. With that focus, the Urban Shores Working Group was active in their feedback and considerations for design. Other community members were more active during the implementation and monitoring phases, engaging people in the topic while also creating learning opportunities for the community scientists and university researchers. While engaged community members learned about the goals of the CFWs and the support of salmon habitat in the system, the university researchers learned about people’s everyday experience of the landscape and their knowledge of system relationships. For example, the artists were paid community members that shared their perceptions or stories and landscape relationships with others through their art and the explanation of their art.

Aldo Leopold referred to the idea of “land community” that considers human and more-than-human elements as a part of the landscape (1948). This research considered how people design and how design processes might help people acknowledge and be “in community” with more-than-human elements of the landscape. It recognized the need to foster feeling and action to help a greater community that includes more-than-human elements.

When referring to this broader understanding of community, the design interventions of storytelling through design and ecorevelatory design are important in considering how such design decisions can increase positive relationships

between humans and more-than-humans. Landscape literacy refers to the ways people relate to the history of the site and understand the storytelling through the site design. Ecological literacy considers how people understand the more-than-human systems of the site and their relationship to them. From a holistic perspective, fostering place attachment among site users typically requires foundational landscape literacy and ecological literacy. This study demonstrates that people can form those deep relationships through community engagement. However, it indicates that while design alone may have some impact on people’s awareness and perceptions of the landscape, it is not adequate to foster place attachment in the general populace.

Identifying ways to engage people in the project in multiple contexts greatly contributed to the feasibility of the in-situ ecological research project as well as its socio-ecological lessons. Multiple individuals and groups generously contributed to the completion of these projects. Floating units would not have gotten permitted without the support and local knowledge of the Urban Shores Working Group. CFWs would not have been built without the support of EarthCorps’ restoration trainees, University of Washington students, Indigenous youth volunteers, and community volunteers. Environmental research measures would not have been collected without a community scientist joining the team to take measures; this allowed two people to be in the water at a time which was critical for safety. The consistency of community engagement in this project for design, implementation, and observation was crucial. Additionally, the community event created opportunity for general site users to become more engaged in the process and learn more about the space.

4.2 Framework of place attachment

The difference between the general site users and engaged community members’ place attachment demonstrated the importance of having community involved throughout the project processes. Not only was the role the community played essential in getting the intervention completed, it also appears to have strengthened landscape literacy, ecological literacy and especially place attachment. A framework for demonstrating place attachment comes through the acknowledgement of site interventions; understanding of a larger, more-than-human community; and demonstrating care for the environment and proenvironmental behavior.

4.2.1 Site interventions and understanding landscape narratives and ecologies

This design of art, signage, and CFWs were intended to recognize the salmon, native vegetation, water quality health, and aquatic ecosystems found in this landscape. Landscape

elements were added to this degraded site to help people understand histories and relationships people have had within the Lake Washington Ship Canal and its larger landscape system. The design interventions of the CFWs, signage, and art provided brief experiential opportunities for people to interact with the story of the landscape.

Those who were closely connected to the project demonstrated more knowledge about the site and its contextual system narratives. Indigenous people shared their history of the land through art focused on salmon and ecological health. Engaged community members demonstrated a different level of landscape literacy and ecoliteracy than those who just passed through the space. Those who helped build CFWs knew of the importance of more-than-human elements in the landscape. If they did not previously know about the aquatic ecosystem, they learned about it in the process. Many shared their desire to continue to protect the salmon.

Compared to general site user responses, engaged community member responses showed stronger connections to the landscape, greater understanding of a holistic landscape system, and improved care for more-than-human elements. People who participated in the design, implementation, and research became invested in the project and system. They built greater relationships with more-than-human elements and experienced greater connectivity to the larger system. The engaged community may have come with some of those values and relationships, but their show of care and expenditure of time strongly demonstrated those relationships in new ways or in new landscapes. It may be that if the ecorevelatory design elements were more visible, permanent or of different construction, more general site users would have become more aware of the significance of the site interventions as well. In this case, it was the engaged community members who most strongly demonstrated an understanding of the site's history and ecological importance.

4.2.2 Demonstrating place attachment and care

This study showed the importance of community engagement in creating place attachment to the landscape. Place attachment is rooted in people's connections with holistic systems, leading to healthier interactions between human and more-than-human elements. Knowledge about critical interactions between elements for landscape system health can foster human connections to place. A sense of place often develops from human relationships with other elements, and their knowledge about them; that knowledge forms a place identity people relate to within the landscape. Place identity is among the components that lead to place attachment (Manzo and Devine-Wright 2012). Place also

refers to the “safe and familiar” feeling and personal relationship people have in an environment (Tuan 2013). In typical place attachment theories, the feelings acknowledged by humans reflect safety, security, fear, peace, and health for people. Through the foundations of landscape and ecological literacy, place attachment can come from environmental education, sense of wonder, and exploration of a place. A sense of place also comes from being local and a part of the system flow (Carpenter 2013) as well as from memories associated with a place (Cooper Marcus 1992). The better people can identify and relate to a place, the greater their connection to its elements and relationships. Consequently, a stronger place attachment may develop.

In understanding place, people can find peace, restoration, responsibility, and relationship to something larger than humans (Orr 1992). The relationship with place should be mutually beneficial between human and more-than-human elements while pushing humans to care for the more-than-human elements. The understanding of place also grounds proenvironmental behavior. Such thinking seeks to consider more-than-human elements and relationships in the system while minimizing human impact that harms more-than-human elements (Kollmuss and Agyeman 2002). There is a connection between a sense of place and an environmental ethic (Senda-Cook and Endres 2013). Environmental ethics, like ecofeminist ethics, derive from care and maintain more-than-human elements within the system.⁵ One form of place attachment through a feminist lens is the application of a care ethic to the place (Noddings 2012). Proenvironmental behavior can show care for the system relationships and more-than-human elements in the system. The relationship between human and more-than-human elements necessitates understanding care and finding mutualistic benefits in the relationships.

Community engagement and examples of care that humans have shown in the system demonstrate place attachment in the landscape. By asking site users, “What memories will you take from this place?”, the responses will reveal whether people connect to human or more-than-human elements in the system. Furthermore, inquiring whether site users learned something about the system and now think differently about the landscape demonstrates whether people are discovering system elements and relationships from the

⁵ Ecofeminist ethics was derived from environmental ethics that focuses on the land and feminist ethics that focuses on a care. The land ethic by Aldo Leopold never used the word “care,” but his later actions in life and writings demonstrated a strong care for the environment. I believe there is a connection from environmental ethics to feminist ethics. Environmental ethics focuses their thoughts on ecosystems and the land, while feminist ethics takes a broader view. There is also a strong connection between Indigenous knowledge and relationship with the land and the feminist ethic of care (Allison 2017; Leopold 1966; Swanson 2015).

land around them.⁶ People need to understand the landscape around them to have an environmental ethic. When people were asked why they felt differently, the responses also demonstrated proenvironmental behavior, education, and reminders about a larger system of which humans are a part. Lastly, people were asked, “Would you be interested in being a steward and helping to care of the landscape? If so, why?” The results revealed proenvironmental behavior, a feeling of connectedness, and why they want to contribute. Some responses were human-related while others were more-than-human-related, but most were associated to a demonstration of care for the land.

Community engagement can promote place attachment throughout a project. By engaging community in the landscape’s design, implementation, and stewardship, those actively involved can build place attachment and pride from the completed work. Each site has unique ways to engage community members to increase the caring relationships between human and more-than-human elements. The results demonstrate the impact of community engagement on relationship building between human and more-than-human elements by querying engaged community members with the same questions as general site users.

As landscapes are considered more holistically in the future, community engagement creates the critical link between design and the relationship people have to the designed space.

4.3 Limitations and recommendations

Not everyone who uses a designed site will be an engaged community member. Clear and intentional design strategies like storytelling and ecorevelatory design are pivotal to educate and connect more people with the landscape, helping them to recognize the health and needed change in a system, redefine existing human to more-than-human relationships, and ultimately help move the system in a more holistically healthy direction. Landscape literacy and ecological literacy combine with community engagement efforts to potentially generate place attachment leading to holistic thinking, caring and action for a system.

The Sweetgrass design interventions applied to Seattle’s present-day Lake Washington Ship Canal at the Fremont bridge included CFWs to provide novel salmon habitat and eco-art elements to increase environmental education. While these interventions allowed general site users to perceive the system differently, the impact on their own was limited,

possibly due to their short duration and constrained visibility. This study supports the recommendation that such interventions be permanently installed at a grander scale to have stronger and more widespread impacts. People may have come to better understand the role of floating wetlands in this location if the invasive blackberry that blocked the view of the water were removed and traditional shoreline restoration practices along with the floating wetlands and eco-art were incorporated. Floating wetlands can be a visible educational element and reminder if people know what they are and what they can accomplish in terms of system health restoration.

5 Conclusion

Community engagement can encourage place attachment throughout the phases of a designed project. Engagement with community members in the design, implementation, and stewardship of the work causes those who are actively involved to exhibit care for the landscape and to form their own cultural place identity and connections. The Sweetgrass case evaluation supports Toomey et al.’s (2020) assertion that community science can further increase people’s place attachment. This study indicates that stronger place attachment results from engaged community members than from general site users. Throughout the project, the engaged community showed examples of care (Noddings 2012, p 1) and proenvironmental behavior (Kollmuss and Agyeman 2002, p 240), fostering a stronger personal connection for people to the land and water. As one steward asserted, “I like to always be connected with caring for the environment and above all to educate our youth on the protection of our ecosystem.” Engaged community members like this steward focused on improving the relationships and interactions with more-than-human species through their involvement with the project.

The Sweetgrass Project considered community science beyond traditional data collection. Public Lab, a nonprofit organization “pursuing environmental justice through community science and open technology,” defines community science as a “community-led scientific exploration and investigation to address community-defined questions, allowing for engagement in the entirety of the scientific process” (@mimiss and @purl 2022). This Sweetgrass study was intentional about community involvement with a driving concern about the salmon population and habitat in the Lake Washington Ship Canal. The associated Urban Shores Working Group united professionals from science, ecology, design, and fisheries along with regulators and public officials. Non-profit EarthCorps restoration trainees, students, volunteers, and stewards were also engaged community members who helped with the construction and maintenance of the experimental floating wetland prototypes. Stewards

⁶ It is critical to note that while this shows us whether people are learning and recognizing what is around them, many site users were already very educated about the site and felt connections to it in other ways. Hence, it cannot be the only indicator of place attachment developed through this project.

and scientists assisted with data collection and analysis. Community engagement occurred throughout the project by considering the design intervention as part of a larger investigation on system health rejuvenation. Artists contributing to the Sweetgrass Arts project were engaged community members willing to share representation of landscape narratives and promote understandings of relationships with more-than-human elements. Community engagement strategies built upon community engagement work done in the Duwamish Floating Wetlands that strived to involve underprivileged communities and Black, Indigenous, and People of Color (Andrews et al. 2022, p 4). By involving a diverse and engaged community, people contributed their own perspectives and desire to share them with others in their community. Through such system interactions, it becomes possible to show care, connection, and strengthened relationships between human and more-than-human elements in the system.

Including a broad range of community roles in repairing landscapes may increase human education about more-than-human elements. Engaged community responses expressed being “fascinated,” proud, and having a desire to “see this succeed.” They showed this place attachment from the perspective of design involvement, not only through the collection of scientific data. The engaged community demonstrated that they understood the design intervention and acknowledged more-than-human elements in the system.

By examining the socio-ecological system and history of the site, design interventions were implemented to benefit a holistic system. This research suggests that for maximum benefit the community needs to be engaged and collaborative in multiple facets of design interventions. Floating wetlands created opportunities to repair more-than-human and human interactions within the system. Human connection to the landscape was measured to assess landscape literacy, ecological literacy, and place attachment. This study demonstrates that community engagement increased people’s place attachment and connections with the land. The project also promoted landscape and ecological literacy but could have benefited from modifications to adjacent site design conditions to enhance general site users’ perceptions and interactions with the place. This research suggests that implementation of a holistic design paradigm including engaged communities can foster understanding of important relationships and strengthen human connections to a system, to advance care for its overall health.

Appendix A: Landscape biography

In the early 1800s, land in the present-day Fremont bridge area was stewarded by Native peoples. There was a community culture and an understanding of living with the land and of the land. When the land was home to the Coast Salish

peoples, freshwater wetlands and bogs were filled with Wapato, Tule, Cattail, Skunk Cabbage, Devil’s Club, Cranberry, Sphagnum moss, and Crabapple (Sheikh et al. 2019). Indigenous people “fished, hunted, and gathered food” on the land and were known as “people of the water” (Muckleshoot Indian Tribe 2012). Salmon was a food source, and the people knew the importance of caring for natural resources and tending to the habitat to benefit the salmon before they accepted the benefits from the land (Muckleshoot Indian Tribe 2012). Indigenous people have a strong understanding of the environment and their place in nature, self-identifying as members of the land (Kimmerer 2013a). They cared for and tended to the land and habitat as a member of this larger system. They understood the relationships between elements and recognized what elements were essential for the system to persist holistically (Marchand et al. 2020).

Several thousand years before the arrival of European settlers, the water system in the case study area was a small creek which connected xaxču?, “Small Lake,” to wiwalqʷ, “Large, having lots of water,” which ultimately flowed into xʷəlč, “Saltwater” (Sheikh et al. 2019). There was an “Outlet,” gʷaxʷap, near the location that was useful for observing water flows. Although the Outlet area was home to salmon, the present-day Lake Washington Ship Canal was not connected to the Cedar or Sammamish Rivers, where many present-day salmon begin their migration. Out-migrating juvenile salmon swam from the Cedar River into the Black-Duwamish River before reaching the Salish Sea. The land was home to the Coast Salish people who knew the river systems well.

One hundred and fifty years ago, the landscape system changed drastically when European settlers arrived in the area. Land history documents the transformation human and more-than-human elements, as shown in Fig. 2. In 1855, the Treaty of Point Elliot was signed, forcing Native people to live in reservations that were less than 10% of their customary land area and with few survival resources (Marchand et al. 2020; Muckleshoot Indian Tribe 2012). Settlers moved into these areas and seized the resources formerly managed by the Native people. They developed and graded the land to introduce new elements. Shorelines still had some freshwater wetlands and bogs that benefited the salmon habitats. Still, the area soon grew into a European-influenced port town with rivers and coastal areas becoming industrialized.

Industrial growth and colonization are seen in the early image of Fremont found in the Museum of History and Industry (MOHAI) archives, shown in Fig. 2. An 1892 image entitled *Looking North on Fremont Avenue* (Buck 1892) shows the original Fremont Avenue bridge that crosses the outlet. This image characterizes the Fremont community and reveals the European settlement named for John C. Fremont, a Western explorer who based the settlement on an

area sawmill (Buck 1892). The original boundaries of Lake Union and the outlet appear in pre-1900 archive photography (Unknown 1894) along with the characteristics of the land (Unknown 1895). These images indicate that increased development and hardening of the shorelines had occurred, but vegetation such as trees and a natural island in the middle of Lake Union remained. The vegetative shorelines still created opportunities for salmon habitat. The salmon migration stopped at Lake Union, as Lake Union did not connect to Lake Washington. The Lake Washington salmon swam out to the Salish Sea through the Black and Duwamish Rivers. Images of the outlet, presently known as the Lake Washington Ship Canal, were photographed by Webster & Stevens and revealed different characteristics of the water. The 1904 Webster & Stevens image displays a small amount of water, but a straightened stream with potential for eroded shorelines (Webster and Stevens 1904). The images taken in 1915 illuminate how the Lake Washington Ship Canal was a stream meandering with vegetated shorelines that benefit salmon habitat (Webster and Stevens 1915a, b). Native vegetation and gradual water shorelines did provide salmon with increased opportunities for food and shelter (Cordell et al. 2017).

To create a more navigable waterway system for barges and large ships, dredging occurred between present-day Lake Union and Salmon Bay, such that the Lake Washington Ship Canal was opened in 1917 (Chrzastowski 1983). The 1915 image, entitled *Digging the channel for the Lake Washington Ship Canal* by Webster & Stevens, exhibits the deep cut that was made during construction of the Ship Canal and displays the steam shovels and trains used to move earth and dig the canal (Webster and Stevens 1915c). This channel required a new Fremont bridge to be built in 1915 spanning the full channel and supporting greater vehicular, pedestrian, and streetcar use that increased access across the Canal and connected the Queen Anne and Fremont neighborhoods (Unknown 1915). The bridge had massive supports that further hardened the water edges, as shown in City of Seattle's engineer James Patrick Lee's photographs during construction and on the opening day (Lee 1916a, b). The Montlake Cut was also dug, connecting Lake Union and Lake Washington, which lowered Lake Washington so that water no longer flowed out the Black and Duwamish Rivers. This change and redirection of the Cedar River system created a large shift in the waterway systems (Chrzastowski 1983). Lake Washington's shoreline receded by 10 vertical feet, and new shorelines were revealed. The shift in water directions caused out-migrating juvenile salmon to come from their spawning regions upstream and swim through Montlake Cut and the Lake Washington Ship Canal to Elliot Bay.

Conflicts of interest and broken relationships were forming between system elements. As the hydrologic system of

Lake Washington changed, this river became a migration route for salmon coming down the Cedar and Issaquah Rivers (Chrzastowski 1983). These salmon no longer traversed the Duwamish; all migration occurred through the Lake Washington Ship Canal. Salmon needed this pathway as a major corridor; they needed habitat and healthy water conditions to grow and gain nourishment before they out-migrated to salt waters. At the same time, the perceived needs of the people and the dredging of the ship canal became critical to river transportation routes (Sargent 1920). The ship canal, however, was not built to provide the natural, shallow shorelines beneficial to salmon. Consequently, the creation of this canal was at this site the beginning of changing relationships between humans and salmon that were not conducive to the greater landscape. Dredging needed to complete the Lake Washington Ship Canal altered water quality properties. Hardened shorelines could not clean or filter the water like previous vegetation could. Beneficial vegetation that provided shade and cooling for the water vanished.

Indigenous presence in the area also shifted as colonization spread over the land and waterways (Muckleshoot Indian Tribe 2022). As part of the original Treaty of Point Elliot, tribes ceded the land and moved to reservations. They were still allowed to fish, hunt, and gather from off-reservation locations, though the abandoned army bases that became tribal reservations had insufficient access to natural resources protected by the treaties (Muckleshoot Indian Tribe 2022). Access to fish was challenged in the 1960s when Washington state created laws limiting off-reservation fishing and limited Indigenous Tribes to fishing on "usual and accustomed grounds," meaning the reservations (Brown 2018). This severely limited the Native communities' access to food and cultural resources that had been strong for thousands of years. In 1974, after decades of challenging the US government in the *United States v. Washington* case, fishing rights were returned to the Indigenous peoples through the Boldt Decision, which allowed tribes to continue fishing in locations off-reservation, despite state regulations (Muckleshoot Indian Tribe 2022). Unfortunately, the Boldt Decision impacted only federally recognized Tribes, so the local Duwamish, Chinook, and Snohomish tribes remained without rights and tensions persisted (Brown 2018). The area's natural resources have long been critical to Indigenous communities. Their care of the land resources has been imperative to preserving species and elements, including themselves (Muckleshoot Indian Tribe 2022).

As Seattle continued to grow and modernize, urban development near the water increased dramatically. The hardening of the shorelines seen on the *Fremont Bridge on Opening Day of Lake Washington* image from 1917 displays the remarkable change from the interconnections that used to exist on the shoreline (Webster and Stevens 1917). Started in the 1880s and bringing 5000 people to the neighborhood, the

sawmill remained active in the 1930s, but it was not the only business in Fremont (Turner 1930). Multiple rail lines served the mill, and other development activities began to dominate the area. Spanning Lake Washington Ship Canal and Lake Union, the Highway 99 Bridge became Seattle's first major highway bridge (Webster and Stevens 1932, 1939). This area quickly became a major development zone for fast-growing Seattle. Barges traveling between Elliot Bay and Lake Washington increased the shoreline's economic development, and the shipping industry provided greater access and travel means for businesses to transport goods using the waterways. Caissons for the Tacoma Narrows bridge (Seattle Post-Intelligencer 1939) and the drydock going under Fremont bridge (Seattle Post-Intelligencer 1944) illustrate the importance of shipping and transportation that emerged with the addition of the Lake Washington Ship Canal.

As urban development expanded, the contaminants flowing into the water increased. In the early 1900s, stormwater and sewer pipes were combined into a single pipe system to route the stormwater and wastewater away from development (ECOSS 2019). During heavy rain events, these pipes overflowed with untreated water and sewage into Lake Union and the Lake Washington Ship Canal (ECOSS 2019). This overflow contaminated the water system with raw sewage, heavy metals from road runoff, and pollutants leaching from rooftops (ECOSS 2019).

The human population of Fremont multiplied, as streetcars and trolley services brought people to the area until the late 1930s when the streetcars stopped running. The area then became less accessible by public transit. Although still standing, the train station was abandoned in 1948 (Davis 1948). With its close proximity to the University of Washington, the neighborhood became a home for the arts community and student life (Curbed Staff 2014). Humans and development dominated the ecosystem and were more concerned about their travel and how the landscape could benefit human life than about their relationships to more-than-human elements. Former railroad tracks were redeveloped into the Burke–Gilman Trail, a 27-mile regional trail system built in 1978 (Davis 1948). The combined sewer system stopped expanding in the 1950s, but old pipe infrastructure and combined sewer overflows continued to contaminate water and reduce water quality (ECOSS 2019). The human relationship with salmon was becoming far more focused on how the humans helped themselves, not on how humans supported salmon or more-than-human elements.

Shorelines continued to be modified with cut and fill practices to add shoreline development and to create hardened edges for people and industry to access the water. Such development created more areas for salmon predators to hide in overwater coverage and removed native plants, and food resources needed by salmon. In addition, fender walls under the Fremont bridge produced shadows, areas where

predatory fish often reside (Ono and Simenstad 2014). The image of the Aurora Bridge from 1939 reveals a very different shoreline condition than before the Fremont Cut was established (Webster and Stevens 1939). These changes were further evident in the MOHAI pictures from 1939, 1960, and 1991. The original shoreline shows soil edges with heavy grading and no vegetation (Seattle Post-Intelligencer 1939). An image from 1960 illustrates the considerable amount of concrete and construction along the shoreline, with some brush along the edge (Seattle Post-Intelligencer 1960). By 1991, steep grading and the addition of fill created development opportunities and more parking spaces (Webber 1991). Loss of native vegetation and an increase in concrete, riprap, and hardened edges persisted. Today, the shoreline continues to change, as the area is home to houseboats and Adobe's Seattle office, leading to further disconnect between salmon and the people.

As technologically-based industries grew in Seattle, development and changes to the landscape increased. By 1994, Seattle started to implement more smart-growth measures to encourage redevelopment in Seattle neighborhoods (Fox 2010). Urban development exploded, new housing and restaurants emerged, and the water was soon simply a backdrop to things happening in Seattle. By 2020, the water had become a playground for yachts, recreationalists, and construction barges. Human elements within the water system now dominate relationships in the system. As of 2018, at least 84% of the combined sewer overflows still presented prevalent problems in this area, generating water quality issues (King County and City of Seattle 2022). Salmon, orcas, and other aquatic elements cannot survive in these toxic conditions. A water quality improvement project is working to lessen the overflows, but aquatic species and water quality properties have been modified significantly over the years. Salmon is an element that people still value but mainly recognize as a food source and something that humans use or dominate. The decline in salmon and more-than-human elements makes apparent the minimal concern for holistic system relationships.

As relationships shifted in the ecosystem, salmon populations significantly diminished (Kerwin 2001, p 12). Until 1991, annual sockeye salmon counts were still above 100,000 each year. Numbers have continued to drop since then with only 15 years being about 100,000 and 2019 being the lowest with 18,625 sockeye salmon (Washington Department of Fish & Wildlife 2023). In addition to the loss of habitat, temperature levels in the Lake Washington Ship Canal rose significantly and dissolved oxygen levels dropped to lethal limits at certain times of the year (Urgenson et al. 2021, p 21). Relationships between critical elements in the ecosystem have changed considerably over the past 200 years. There has been a loss of caring communities that originally defended retaining the more-than-human elements along the shoreline.

Appendix B—Survey questions from visitor survey (general public) and Steward/Artist survey

Sweetgrass Arts - Visitor Experience Survey 2021

Thank you for volunteering to participate in this survey. I am researching how visitors experience this stretch of the Burke-Gilman trail. Please answer honestly about your experience. Your response is anonymous. If you would like to add your email address at the end, you will be entered to win a \$25 Starbucks gift card.

By continuing with the survey, you are agreeing to participate and consent that you are over the age of 18 years old.

How often do you come to the Burke-Gilman trail?

Daily 2-3 times a week Weekly Monthly Infrequent

In this part of the Burke-Gilman Trail, what features may be contributing to a healthy ecosystem?

What art features have you noticed on the site? Do they tell you anything about the site?

Is there a certain art or landscape element that helped you better understand the landscape or ecosystem? _____

Have you participated in tours, stewardship, or community events of the floating wetlands? Yes No

How would you explain the floating wetlands to your friends?

What memories will you take from this place?

Has learning about the floating wetlands made you think differently about the landscape? Yes No
If so, how? _____

Would you be interested in being a steward to help care for the landscape? Yes No
If so, why? _____

Other Comments:

Thank you for participating in this survey! Please return it to Jenn Engelke at jengelke@uw.edu

Sweetgrass Arts - Steward and Artist Survey

Thank you for volunteering to participate in this survey. I am researching how people experience this stretch of the Burke-Gilman trail. You have a unique experience having participated in creating the floating wetlands or the art. Please answer honestly about your experience. Your response is anonymous. If you would like to add your email address at the end, you will be entered to win a \$25 Starbucks gift card.

By continuing with the survey, you are agreeing to participate and consent that you are over the age of 18 years old.

1. How did you participate in Sweetgrass? Choose all that apply.

Check all that apply.

- ☐ Artist
☐ Stewardship
☐ Design Implementation
☐ Research team
☐ Other: _____

2. If you are an artist, what is the inspiration behind your art?

3. If you are a steward or helped with the design implementation, what was your reason for being involved?

4. Is there a certain art or landscape element that helped you better understand the landscape or ecosystem?

5. How would you explain the floating wetlands to your friends?

6. What memories will you take from this place?

7. Has learning about the floating wetlands made you think differently about the landscape? Yes/No If so, how?

8. Would you be interested in being a steward to help care for the landscape? Yes/No If so, why?

9. Other comments:

10. Thank you for participating in the survey! If you would like to be entered into a drawing for a \$25 Starbucks gift card, please enter your email below.

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Data availability The data that support the findings of this study are available, but restrictions apply to the availability of these data. Please contact authors with reasonable request and permission information.

Declarations

Conflict of interest The authors declare that they have no conflict of interests relevant to the content of this article. This manuscript “Meas-

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