Spaces for People and Salmon along Restored Urban Shorelines:

A Critical Reflective Analysis

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Abstract

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Restored urban shorelines have social and ecological value even in polluted and industrialized contexts, but the relations among people, the land and water, and other species are not often studied, nor are the social benefits that these shorelines hold for different groups using these spaces. A two-part study of six restored shoreline sites on the Duwamish River was conducted to address this gap. First, point-intercept intertidal plant surveys were conducted and habit characteristics were assessed. Second, interviews were carried out with people spending time at shoreline sites, and findings were further supplemented with information collected through participant observation and interviews with key community informants. Findings were synthesized to elucidate relationships between physical, ecological, and social site parameters. The results of this analysis can be used to inform restoration practitioners, community organizations, and city and county planners about opportunities for improving existing and future habitat restoration sites in the Lower Duwamish River and similar geographies.

This thesis contributes to literatures on urban estuarine habitat restoration and social-environmental ethics, by outlining and testing a method and approach that supports the integration of intentional human use and access to restored shoreline sites in highly developed areas, where marginalized communities have little access to green spaces.

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INTRODUCTION

South of downtown Seattle, set back from the road about 100 yards across a yellow field of dead grass and flanked by Seattle City Light power station, a line of trees and shrubs stands whimsically in the distance. It is a welcome, if out of place sight in the surrounding area dominated by grey and steel. Beyond the trees, a small, unexpected blue-green sanctuary brightens the deadness of everything around it. This novel marsh habitat was built by people and machines, and is an attempt at a stand-in for a once thriving natural estuary, where insects, heron, salmon, and seals can find food and shelter. At first glance, it looks somewhat natural… but what does it mean for something to be natural? If you think of your favorite place to go as a kid that was near home, is this place outside? If it is, would you label or consider it to be nature? In most urban and human-dominated areas, there is a shortage of what we traditionally think of as nature. But if we look differently at the grey-green spaces in urban environs, we may notice that there is more nature than first meets the eye, weaving its way through cracks in the pavement and breaking through concrete rivers.

It is worth examining what it means for something to 'qualify' as nature. As humans continue to damage the planet to support a growing population and global economy, the practice of ecological restoration is also growing (Hobbs 2013). How we view nature impacts how and what we choose to restore, create, enhance, and rehabilitate. It is crucial for scientists, practitioners, and community groups to examine not only the ecological outcomes, but also the broader and potentially unexpected social impacts of restoration efforts. The goals and motivations driving restoration are equally if not more important than the outcomes. (Bergen et al. 2001, Higgs 2003, Higgs et al, 2014, Hertog and Turnhaut 2018). In urban areas, there may be direct social benefits of restoration for local communities, as former concrete lots or derelict properties are transformed into green spaces that come to be enjoyed. This increased connection to restored natural spaces in the local landscape is critical for ongoing community support and investment in future urban restoration projects. If policy and regulatory mandates dissolve, then community support will be integral to the implementation of future projects (Simenstad et al. 2005).

Thriving urban nature and human-engineered natural habitats have not become as widely recognized or held in the same regard as the grand wilderness, landscaped parks, or idealized tropical forests. This is especially true when assessing what prominent conservation organizations choose to protect and place on the global stage (WWF n.d.). As more people are living in urban environments than ever before (UN 2018), the importance of spending time in green spaces has gained some much needed attention (Brook 2010; Shanahan et al. 2015). Yet, the majority of ecological research is conducted within nature preserves or protected areas, which make up less than 1/8 of the global landscape (Martin et al. 2012). These ecological biases may impede conservation and restoration efforts in the 75 percent of the world where people live and work. It is crucial that more ecological studies take place in urban spaces if we want to improve restoration outcomes in these areas.

In the Pacific Northwest, there is definite interest and action taking place to improve the health and understanding of urban natural areas and the Puget Sound broadly. Salmon Sense, the Northwest Indian Fisheries Commission (NWIFC), and local grassroots organizations like Dirt Corps and the Environmental Coalition of South Seattle (ECOSS) are taking on the challenge of tending to urban green spaces and natural resources. Many work collaboratively with local communities and representatives of tribes including the Duwamish and Muckleshoot. The Duwamish Alive Coalition and Puget Sound Partnership have functioned as a lead coordinating bodies for improving the health of the Duwamish River and Puget Sound as a whole, respectively. This research takes place in the Lower Duwamish River, where previously developed shoreline spaces have been converted to habitat for juvenile salmon.

City and county governments, the Port of Seattle, and industry (e.g. The Boeing Company) have also implemented numerous urban estuarine habitat restoration projects. These actors and other industries were compelled to undertake environmental mitigation action CERCLA and findings of federal National Resource Damage Assessment mandates (Sutter 2013). The Endangered Species Act helps to drive restoration along the river specifically for juvenile Chinook salmon (Jensen et al. 1997; Kern et al. 2015). Regardless of the implementing body, many restoration projects within Puget Sound and the Lower Duwamish River estuary include the removal of shoreline armor, removal of toxic sediment, intertidal and upland planting, and/or the placement of large woody debris (LWD) to stabilize muddy banks, and to provide shade for juvenile salmon at high tide (Duwamish Blueprint 2014). Enhancing the growth potential of juvenile Chinook salmon is a key goal of estuarine habitat restoration in the LDR (Cordell et al. 2011), and growth in this early life stage is an important determinant of later marine survival (Duffy and Beauchamp 2011).

While restoration in urban areas is well-meaning, it can lead to unintentional harm to marginalized groups. As urban areas become cleaned up and beautified, gentrification and displacement often follows (Anguelovski 2016). In the Lower Duwamish River basin, the amount of green space is lower than any other part of Seattle, and many people do not have the means to access green spaces outside the basin (S. Kavage, personal communication). Additionally, the ways in which people use and value urban industrial shorelines is also understudied.

There is still room for improvement in how cities, counties, and organizations plan for and prioritize restoration projects that create, enhance, or restore urban green spaces. Ill-defined goals are often a part of the problem, and including diverse perspectives early on can strengthen outcomes (Hertog and Turnhaut 2018). Refining restoration goals is a good first step in improving outcomes for both people and the environment. This work seeks to highlight the importance of treating restored urban shoreline sites as social-ecological systems, so that planning and monitoring incorporates considerations not only for fish, but also for human use and how it is mediated by plant and other site features.

Purpose of this study

As the above introduction has shown, urban shorelines have social and ecological value even in polluted and industrialized contexts, but the relations among people, the land and water, and other species are not often studied, nor are the social benefits that these shorelines hold for different groups that use these spaces. To fill that gap, I conducted a two-part study of six shoreline restoration sites on the Duwamish River, assessing intertidal plant communities and fish habitat conditions and characterizing their social value. Though several of the shoreline habitat sites created in Duwamish River estuary are now over ten years old, the current status of the intertidal vegetation and changes over the years have been minimally or poorly documented over time (J. Cordell, personal communication). I directly address this data gap through the field identification and analysis of over 950 intertidal plant observations across four restored shoreline sites. Furthermore, neither pre- nor post-project monitoring of how people use and value the sites has been conducted. I directly address this data gap through field interviews investigating the ways in which people engage and connect with these restored urban shoreline spaces, and how site design, plants, and other parameters contribute to their experience.

This thesis contributes to literatures on urban estuarine habitat restoration and social-environmental ethics, by outlining and testing a method and approach that supports the integration of intentional human use and access to restored shoreline sites in highly developed areas, where marginalized communities have little access to green spaces.

The thesis unfolds as follows. First, I engage with literatures on concepts of nature, ecological simplification, and estuarine habitat restoration in an urban context, and describe the framework, research questions, and detailed methodology. Second, I provide a detailed baseline and analysis of previously unstudied intertidal plant communities at four differently-restored shoreline sites in the Lower Duwamish River estuary. Next, I provide an account and analysis of human use and perceptions of numerous sites along an 11-mile stretch of shoreline. Finally, I discuss how this analysis can inform grassroots organizations, city and county planning bodies, and community members about opportunities for improving existing and future restoration sites in the Lower Duwamish River and similar geographies.

1 BACKGROUND

1.1 What is Nature?

Depending on who you ask, you might hear very different ideas of what nature means, or what qualifies as nature. Nature is the ever-elusive untouched wilderness area, or a mythical place "where the sidewalk ends" (Silverstein 1974). Nature is also a second-growth forest with hiking trails built and maintained by humans. There is the romantic, pastoral nature of bucolic farms and countryside. And there is another, perhaps less common view of nature, coexisting with humans in the expanding urban jungles of the world. The grander and wilder forms of nature have our attention, without question. But what about the flowers popping up through cracks in derelict lots, or the many meager streams winding through the backyards of our cities and towns? These less grandiose form of nature are in need of more recognition.

Though nature exists on a spectrum, many modern perspectives continue to view it as being "out there" (Marris 2013), more so than all around us. Focusing solely on this wild nature aligns more with the "elite preservationism rooted in settler colonialism" (Garvey 2016) and devalues the more proximal and tangible kinds of nature. In the book *Rambunctious Garden*, Marris presents cases for a new way of seeing nature. She argues that nature is everywhere, but it's not pristine anywhere. She posits that "we've lost a lot of nature in the past 300 years—in both senses of the word *lost*". Yes we have lost nature in the literal "paved paradise, put up a parking lot" manner as Joni Mitchell sang in 1970. This is still a common narrative, but maybe more importantly, we've lost nature in that "we have misplaced it... we have hidden nature from ourselves". From potted exotic plants on city street corner, to the edible, so-called weeds like dandelion and burdock encroaching on gardens, to the concrete rivers of the world (Rodriguez 1991)—perhaps nature is hiding in plain sight.

Beyond thinking about what nature *is*, it is crucial to consider the worldviews that are held regarding whether humans are *a part of* or *apart from* nature (Leopold 1949). Some traditions, communities, scientists, and other groups of people consider themselves as coexisting with the Earth and "more-than-human others" (Asdal et al. 2016)**.** This perspective is both an old-world and recently resurgent concept. In many Indigenous traditions, plants and animals are more than just species; they are regarded as persons or members of the extended family, assembling into nations as humans do. This idea goes further for some tribes like the Anishnaabee, who regard water, rocks, and other non-living entities as life forms (Reo and Ogden 2017). Lonnie Kauk, a direct descendant of the Ahwahneechee Tribe and skilled rock climber raised in the same valley as his mother, whispers to the crack in the rock as he climbs the infamous To-tock-ah-noo-lah, asking for passage and giving thanks (Alpinist 66). When people operate from the understanding that rocks and plants are considered kin, it is unsurprising that they act with reciprocity toward these beings.

Aldo Leopold, widely recognized as a visionary conservationist, formulated the oft-debated *evolutionary ecological land ethic,* which was introduced 70 years ago, in 1949 (Williams et al. 1997, p. 20). Leopold's writing in *A Sand County Almanac* wanders back and forth between pondering the wonders of the land and philosophizing about humans' place in it, in a similar way that a brook wanders over and around rocks. He often critically compares fish or birds or trees to people— "how like fish we are... eager to seize upon whatever new thing some wind of circumstance shakes down upon the river of time!" (Leopold 1949, p.42). He compares the "devices" of pines to ways of governments— discarding new needles in intervals and implementing overlapping terms of office, respectively, to "achieve the appearance of perpetuity" (Leopold 1949, p. 92).

It has been argued that Leopold's land ethic treats humans as a part of the land, or "plain members and citizens of biotic communities" (William et al. 1997), though this is not entirely evident throughout the book. Leopold writes that "men are only fellow-voyagers with other creatures in the odyssey of evolution" and that "this knowledge should have given us... a sense of wonder over the magnitude and duration of the biotic enterprise" (Leopold 1949, p.117). But, he also proclaims that "not all trees are created equal" and notes his own paternalistic biases when choosing which tree to harvest, that is, whether to chop a pine which he himself planted, over a birch, which "crawled in under the fence and planted itself"— he always chooses to chop the birch, in this case giving preference to preserve that which he tended to with his own hands (Leopold 1949, p.73).

Many individuals and institutions in modern societies view and position themselves as entities separate from the rest of nature, actors upon it and controllers of it. From this vantage, nature is an instrument— something to use solely for our benefit, or at best, something to be cared for so that we may extract from it what we need. While some people living in western and capitalist societies might say they disagree— that we should care about nature for its own intrinsic value-- policies and management agendas often suggest otherwise. Even environmentally focused, progressive U.S. cities like Seattle and San Francisco tend to align with narratives on protecting and enhancing nature for the ecosystem services it provides, disparately to middle and upper class communities. The numerous and extensive initiatives to support juvenile and adult salmon in the Pacific Northwest stem in part from the taste for and reliance on them as a food source (J. Rasmussen, personal comm. 2018), and largely due to their protection under the Magnuson Stevens Act (MSA) and the Endangered Species Act (ESA) (Waples 1991), and tribal fishing rights. This type of species-driven or biocentric conservation (Hertog and Turnhaut 2018) would arguably still occur without the legal mandates to preserve the size of the (fish) pie (Brown 1994).

When taking action to protect nature, does the end justify the means— should it matter *why* we protect, conserve, or restore certain animals, habitats, or ecosystems? A case can be made on both sides of this argument. If political will in a capitalist society requires that protection and restoration focus on the "world's stock of natural assets", or natural capital (WFNC, n.d.), at least this framing achieves the goal of protection for nature. But what kind of world values nature only as an *asset?* Left unchecked, this mode of thinking may further erode a collective sense of appreciation and reciprocity for nature. It risks leading to a greater disassociation with the greenness in our immediate surroundings as an important kind of nature, and thus worth our attention, time, and resources.

The nature of the Duwamish River is not impressive in the way that impressive nature is typically viewed and portrayed by the Western conservation community and ethos. In the Duwamish, there are no sweeping fields or giant slabs of rock towering over head. But there is a flurry of wildlife activity in and around the narrow river—Caspian terns swooping down for small fishes, river otters sneakily climbing onto engineered floating wetlands to discard the heads of flounder, and kingfishers, great blue heron, and osprey coloring the sky and shorelines. Piles of pink, blue, and white shipping containers and a massive, grey concrete plant serve as a perfectly contrasting background. Seals and sea lions can be spotted almost daily, as their heads pop up above the surface once the wake of a cargo ship has subsided. And in later summer and fall, there are flashes of shining silver that fill that space above the invisibly polluted river, as salmon migrate homeward. The salmon's shimmering sides are an elegant reminder that the urban nature running through our own backyard is worth looking at, worth noticing as nature worthy of our attention and care, and that it has much to offer those who look in return.

2 PROBLEM SITUATION AND SETTING

This section introduces a brief history of problems of ecological simplification in the Lower Duwamish River estuary for humans and the environment there today, as they relate to social-ecological habitat restoration in an urban context.

2.1 Ecological Integrity and Ecological Simplification

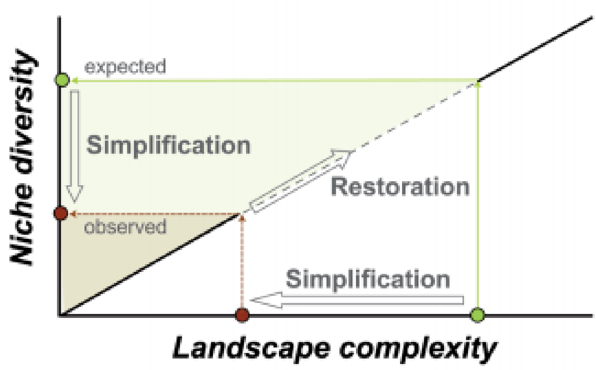
Let us consider a place that is not conspicuously grandiose, but is considered to be nature— say, a small tidal marsh, situated in an increasingly populated suburban area outside a major city. Biologists and ecologists might want to study the condition of the marsh relative to how it once was. They may consider if the animal and plant assemblages found within the marsh are of a similar makeup as they were 10 or 50 years prior, and the mechanisms resulting in differences. In urban ecology studies, it is difficult to precisely assess how surrounding development and human use impact natural or restored areas (Werner 2011). Further, in a world where humans have been altering the landscape for tens of thousands of years, what exactly *is* natural? Put another way, the questions then becomes, 'what *should* a particular habitat look like'? This is a question that ecologists and restoration practitioners must consider when conducting studies and making decisions about how to manage land.

When assessing the health of a particular habitat, scientist may report on ecological integrity, which is almost like a report card for nature-- how well is it doing? Ecological integrity, from a restoration perspective, can be defined as the ability of a particular area to support a balanced and adaptive assemblage of plants and animals whose "composition, diversity and functional organization is comparable to that of natural habitat of the region" (Karr and Dudley 1981). By this definition, scientists must determine what *natural* means, or what the historical baseline is, in order to determine if the area of study has maintained or achieved ecological integrity (Guerrero-Gatica et al. 2019). Historically, when making ecological assessments and decisions, researchers and managers are often comparing current conditions to some established baseline. However, the former gold standard of 'restoring to a baseline' is changing, particularly in urban and human-dominated landscapes where historical data is lacking or insufficient, or a historic baseline is no longer an achievable or appropriate target (Simenstad et al. 2005; Yu et al. 2010). That is, rehabilitation must be an acceptable goal, rather than restoration in a more literal sense, i.e., attempting to return a habitat or ecosystem to conditions that once existed.

Any baseline can serve as a useful point of future comparison; if one wants to monitor change, some record of what's present is certainly needed (Hunsaker et al. 1989; Sinclair 1998). However, the standard use of ecological baselines in the context of rapid environmental change, and when modifying or restoring nature involves value-laden choices (Hertog and Turnhaut 2018): what *should* this landscape or habitat look like; what animals and plants *should* be supported or transported here? Ecologists and managers are facing new philosophical questions about how to employ baselines, manage potentially invasive species, and when to consider assisted migration. Should the plants at a novel, modified marsh habitat mirror those that have occurred there 150 years prior? Practitioners must collectively decide what criteria to use to address such a question. As average and extreme annual temperatures rise, and mountain-dwelling animals like the pika climb higher to stay cool enough to survive, should humans assist their migration to a taller mountain, before they can no longer survive where they're located (Wilkening et al. 2015)?

Moving forward from ecological integrity, there is the concept of ecological simplification, which, simply put, refers to a degrading or unhealthy habitat. Peipoch et al. 2015 discuss the causes and consequences of the problem of ecological simplification within the context of a riverscape. They argue that ecological simplification occurs "when structural changes to landscapes result in loss of niche diversity". Niche diversity is an evolutionary process, but can be thought of as the number of functional places within a given habitat, or how many individual species may occupy an area at all trophic levels. The loss of niche diversity may result in lower "relative yield total", or the amount of biomass of each species (Carroll et al. 2011). Though the ecological mechanism is not always evident, there may be a decrease in total primary production.

Figure 1 (below): Ecological simplification as a function of reduced landscape complexity and decreasing niche diversity within a defined area. Taken from (Peipoch et al. 2015)



In one sense, ecological simplification is a form of destruction that is partly a consequence of earlier European movements to simplify and order the world, as discussed by Tsing et al. 2017. For instance, during the Enlightenment and Reformation periods, the increasingly complex world was simplified—it was ordered and categorized; "category-crossing monsters" were campaigned against and banished. Through this ordering and rationalizing of our world, autonomy was held as the golden standard. This concept did not stop with the alienation of individuals-- it infiltrated "landscape-making practices", which "imagined the world as a space filled with autonomous entities"—in other words, plants and animals as individual species (Tsing et al. 2017).

Landscape-making practices also include the alleged simplifications afforded by industrial farming— the production of a single species, exclusively, i.e., the monoculture. It turns out these attempts at simplifying production are not so simple in the long term. When aquaculturists attempt to grow and farm a long-distance swimming predator in a massive pen, they must also grow or collect its food, feed it, and manage a whole suite of cascading problems, such as exploding populations of parasites (Taranger et al. 2011; Fløysand & Jakobsen 2017). Those parasites must be culled by other smaller species, which must be collected or grown, and so on. Life does not and cannot exist in independent units. Yet, many modern day restoration projects focus on actions targeted at improving conditions to support a single species, as is the case with Chinook salmon in the Green-Duwamish River (Duwamish Blueprint 2014).

2.2 Change in the Green-Duwamish River

There is a story of ecological simplification in the Green-Duwamish River. Or perhaps, many stories. Let us begin at majestic Mount Tahoma, standing in "'grandeur and mass' beneath a sea of shifting snow dunes" (Moore & Leavell 2016), or Mount Rainier as many know it today. The Green River headwaters begin 30 miles northeast of here, and flow west and northwest through dense forests, the banks sloping steeply downward into the narrow valley. Many tributaries flow into the river, as does the North Fork of the Green River. Continuing onward through the rugged land, the river is halted by Howard Hanson Dam, around river mile 53 (WDFW Duwamish Basin, n.d.). Here, we will also halt the story, to return to a time long before that of this and other dams.

In the mid-1800s, the Green-Duwamish River delta was a wide swath of thousands of acres of wetlands, marsh, and tidal mud flats. The river, tidelands, and upland areas provided ample food - deer, plants, shellfish, and more for Coast Salish people, including the Duwamish Tribe living along the river and within the basin (Burke Museum 2013). This time period, near the middle to end of the 1800s, begins the story of ecological simplification of the area, as white settlers began to arrive. Settlers were determined to colonize and capitalize on the bounty of the area, at any cost. In the language of an army lieutenant surveying the land in 1853, "when the tide is out the table is spread" (Klingle 2005). The intentional, sweeping changes made to the landscape in the name of industry, trade, and progress are complex, and almost unimaginable. The story has been told by many voices: people of the Duwamish Tribe, industrial tycoons, historians, biologists, and local journalists over decades.

Klingle, 2005, offers a critical account of these geographic transformations, displacement, and resultant societal shifts in the region. He calls to light the fact that, while many historians are increasingly focusing studies on cities, that is not the case when it comes to the history of the manipulation of water within "town limits" and resultant distributions of power. On the brink of ecological simplification, Euro-Americans employed a preemptive form of reduction of the land and control over access, through mapping and private property allocations. Settlers were determined to rebrand the river as a place for agriculture and commerce, and later as a place for railroad tracks. However, the watershed resisted these attempts at control through the 1870s, via seasonal flooding and salt water intrusion. For decades, into the early 1910s, ditches, dikes, draining, and dynamite all proved to be ineffective at reshaping the complex watershed in a way that suited the needs of settlers. However, the land was already deteriorating from a health perspective, with fewer and fewer shellfish in the tidelands and other sources of food beginning to decrease as a result of human attempts to prosper from the Earth.

The complex network of marshes and once bountiful wetlands, and the Indigenous people who lived on and with this land, were altered in ways that have left little trace of what once was. After many failed attempts at control, the rerouting of the Black and White Rivers is what finally led to dramatic physical transformations of the landscape (Klingle 2005). Over a period of less than a decade, the once beautiful and fruitful tidelands of the river delta, of spiritual and tangible importance to the Duwamish people, were transformed by settlers into the world's largest manmade island, "ready for industrial tenants" (Thrush 2006). Sediment dredged from the river was used to fill in the tidelands, and over 4,000 acres of wetlands were ultimately converted to developed land.

The details of social and environmental injustice are minimalized or left out altogether, depending on who is telling the story. For instance, in the History of Urban Planning in Seattle, there is a *single paragraph* devoted to what happened "before white settlement", and there is no mention of wrongdoing, either by the settlers, or later, city planners that further harmed the ability of Indigenous people to maintain their former way of life (Thrush 2006; Seattle Planning, n.d.). But the Duwamish people were driven by settlers from the river now named for them. They, along with other tribes such as the

Suquamish and Muckleshoot, were displaced off their lands, sometimes by fire, as in one set to the communal longhouses in which they lived (State of Our Watersheds 2012). Having no land of their own and being unwelcome or driven off again by settlers in new places where they landed, they often ended up on the fringes-- beaches, sand spits, or marginal strips of land upon which there were decreasing opportunities for hunting and gathering.

In present day Seattle, part of the Lower Duwamish River, once the center of life for Indigenous communities, is now more of a fringe area, despite its geographical standing in the middle of the southern part of the city. The people living near and utilizing its polluted shores are often lower income, immigrant, or otherwise disadvantaged (Action Plan 2018). The straightened and filled lower section of the Duwamish River empties into Elliot Bay near Seattle's bustling waterfront, about 65 miles from its origin. Within the river, an impressive mix of shoreline uses occurs in a five mile span, namely heavy industrial, commercial, and residential (Duwamish Land Use 2013). The shoreline is peppered with small bits of engineered natural areas that have morphed into novel habitats in the many years since their inception. These restoration efforts were required by law as an attempt to mitigate the damages done by Boeing and other private industries, the city of Seattle, King County, and the Port of Seattle during periods of less-regulated industrial use, where dumping toxic waste into the river was the norm.

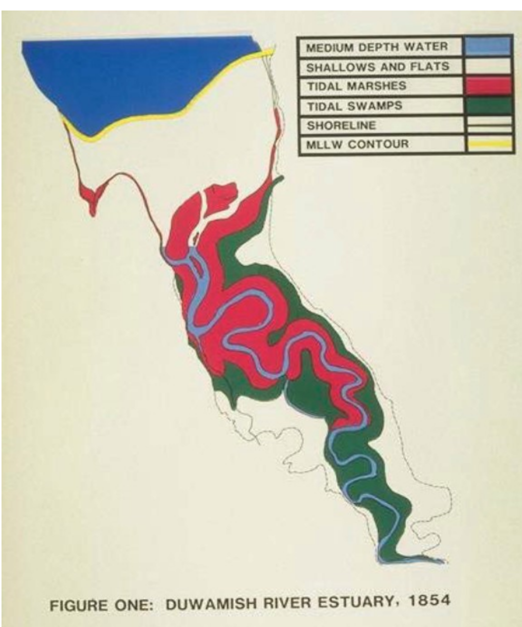


Figure 2 (left): Historic conditions in the Duwamish estuary 1850. Taken from Seattle.gov.

Figure 3 (right): Present day conditions in the Duwamish River estuary. Taken from the Burke Museum Waterlines Project.

While development and port activity have contributed to a strong economy for the state, the environmental damages that were incurred during heavy, unregulated industrial periods between the 1920s and 1960s continue to impact the river and local communities. It has been challenging to successfully remove toxins that are buried in sediments and continue to leach into the water (DAC, NOAA). Unfortunately, Boeing continues to discharge illegal levels of PCBs, as permitted by the Clean Water Act (Mapes 2018). Relentless volunteer and grassroots action, such as organizing community meetings, habitat planting events, river clean ups, and vision plans for a thriving Duwamish River Basin continue to grow (Action Plan 2018). Beyond the problem of toxic sediment, the filling of marshes, straightening of the river, and subsequent shoreline armoring have resulted in the loss of critical nearshore habitat for juvenile salmon (Toft et al. 2014).

2.3 Estuaries, Juvenile Salmon, and Shoreline Restoration

Estuaries provide a crucial transition zone for juvenile Pacific salmon, where they feed, rest, and adapt to salt water as they migrate from rivers to bays and oceans (Duffy & Beauchamp 2011; Toft & Cordell 2016). Salmonid species (salmon and trout) that migrate through the Lower Duwamish River estuary include coho, Chinook, chum, and steelhead. Within a given estuarine area, there may be a variety of aquatic habitats, each ranging in abiotic factors such salinity, depth, substrate type, concentration of dissolved oxygen, and flow levels (Weitkamp et al. 2014). The specific role of estuaries varies for different salmonid species and types. For instance, juvenile Chinook salmon (*Oncorhynchus tshawytscha*) tend to have longer residence times in estuaries (Healey 1991), where they spend more time feeding and undergoing physiological changes that prepare them for salt water, as compared to other species (Simenstad et al. 1982; Bottom et al. 2005). Early-stage fresh water and estuarine growth influences Chinook salmon growth at sea (Ruggerone et al. 2009, Duffy & Beauchamp 2011) and often, salmon that do not reach a critical size before the end of their first summer in a marine environment do not survive the following winter (Beamish et al. 2001).

The Lower Duwamish is one of many estuaries in the United States that has been reduced in size and quality by human development, thereby reducing the availability of specific habitat attributes that are critical for the early life history stage of salmonids. An example of high quality habitat is an off-channel area with: shallow mud flats, lower flow rates, vegetation that supports primary production, and cover from logs that provides shade and protection from predation (Simenstad et al. 1982; Bottom et al. 2005). Marsh plant communities, including rushes, sedges, and aquatic plants, provide primary production that supports insects, larvae, and other invertebrates that are a crucial food source for outmigrating juvenile salmon (Cordell et al. 2011). However, armored shorelines can diminish the availability of high-quality habitat.

Shoreline armoring reduces the horizontal area where wetland plants grow, thereby limiting primary production, and eliminates or decreases shallow water zones where small fish can escape larger predators and have enough light to see their prey (Toft et al. 2014; Dethier et al. 2016; Munsch et al. 2017). There are many types of armor, from vertical concrete sea walls, to bulkheads, to riprap (large jagged boulders) and other revetments. Shoreline armoring is highly prevalent in most urban coastal areas, and can be traced back to 448 A.D. to the Eastern Roman Empire, where sea walls were built to protect the city of Constantinople, now Istanbul (Manners 1997).

Photo (below): aerial photo of intense level of port and industrial activity in the Lower Duwamish River, where 95% of the banks are armored. By Bettina Hansen. Taken from The Seattle Times.

In Puget Sound alone, there is over 700 miles of armor, which accounts for about 29 percent of all Puget Sound shorelines, and equates to the entire length of the Washington and Oregon outer coasts combined (PSP

2018). There is a much higher concentration of armor in central and southern regions, particularly in and around Seattle within Elliott Bay. In the Lower Duwamish River, 95 percent of shorelines are armored, and riprap accounts for about 65 percent of all armor (Morley et al. 2012).

Photo: typical riprap armoring in the Duwamish River at high tide, at Terminal 108.

In the Puget Sound region, low numbers of Chinook salmon populations and the determination that they constitute an Evolutionarily Significant Unit (ESU) enabled them to be listed as *threatened* under the Endangered Species Act (ESA) (Myers et al., 1998). An ESU indicates that the population of salmon identified is reproductively isolated from other populations of salmon, and that it is evolutionarily important to the species (Waples 1991). In the Green/Duwamish River basin alone, around 16 million juvenile salmon are released from hatcheries every year (Wulff 2019), including over six (6) million Chinook salmon. The summer/fall stock of Chinook is considered to be doing well, with around 11,000 - 15,000 spawning adults returning annually. This number is still only about one third of the historical returning population (NMFS 2006). In the Green-Duwamish River and other rivers and watersheds that have suffered from habitat loss and contamination, restoration actions aim to create or improve habitat with the explicit purpose of increasing the survival and stock size of salmon over time. Tribal fishing rights, the ESA, the Magnuson-Stevens Act (MSA), the Clean Water Act, and other policies continue to drive cleanup along with habitat creation or rehabilitation efforts (Simenstad et al. 2005; Duwamish Blueprint 2014). WRIAs 8, 9, and 10 have been implementing the Puget Sound Chinook Recovery Plan since 2005, and progress has been slow (State of Our Watershed 2012).

Restoration actions vary depending on the section of shoreline within the river. Actions begin with a lot of removal, including the removal of: shoreline armor, fill material, tons of rubble, contaminated sediment, buried debris, creosote piles, tidal gates, overhanging buildings, docks, derelict vessel hulls, and grounded barges. Following and/or coinciding with removal, there is a lot of regrading, or ensuring that bank height and slope along the shoreline will result in intertidal habitat space. Regrading leads to the creation of habitat intended to support outmigrating salmon, including wide shallow water mud flats, narrow off-channel habitats, and vegetated shorelines (Duwamish Blueprint 2014). Upland trees and shrubs along with emergent intertidal vegetation is put in place, though detailed reports of what has been planted during the original creation of the sites and in subsequent years are often lacking, depending on the primary group or agency in charge of the restoration (J. Cordell, personal communication).

While all habitat has been designed with juvenile salmon in mind, physical site development parameters are limited by surrounding conditions (i.e. building, roads, and available space) and site designs also vary based on their location in the river and what is thought to be needed by salmon in particular reaches. Recent studies have shown that creating habitat in developed or impaired wetlands can enable the return of biological functions (Cordell et al. 2011). However, it is not only the quality of habitat, but also the use of—and use patterns of—juvenile salmon within the habitat that ultimately determine access to food and refuge from predation. These in turn influence long term growth and survival (Simenstad and Cordell, 2000). The University of Washington's Wetland Ecosystem Team (WET) has conducted numerous studies of juvenile salmon and invertebrate assemblages at restored and control shoreline sites in the LDR. Potential factors influencing salmonid use patterns are briefly discussed in the *Findings and Discussion* section of this work.

See next page.

Figure 4: Armored shoreline habitat (top) and vegetated or restored shoreline habitat (bottom). Art by Beryl Allee, sponsored by NOAA http://shorefriendly.org/shoreline-ecosystem/

Despite the large amounts of time and money spent on habitat restoration, ecological monitoring is often limited by amount of funding, staff capacity, and low prioritization of this stage of the restoration process. It can be time and labor intensive, leading to further de-prioritization from outside funding agencies. Sometimes, the type and location of plants put into the ground do not match the USACE "As Built" documents (J. Cordell, personal communication), depending on what is available, who is doing the planting, and other reasonable logistical challenges of this phase. On smaller scales and especially at sites with community or individual steward maintenance, planting of native species and removal of invasive species is typically not documented, or is at best minimally documented but not readily available.

Recent and detailed vegetation monitoring studies are largely absent. The U.S. Army Corps of Engineers (USACE) has conducted vegetation monitoring, though many of these studies and reports are now over ten years old (USACE Monitoring 2005). George Bloomberg at the Port of Seattle has put in an incredible effort to remove some invasive species and check on the overall site condition and vegetation. While this is an incredible labor of love and likely improves the quality of the habitat, specific plant-related actions are largely undocumented (G. Bloomberg and R. Edwards, personal communication). However, the composition of intertidal plant communities at these sites has not been assessed.

Through discussions with the Wetland Ecosystems Team, I concluded that the condition and assemblage of intertidal vegetation restoration sites within the Lower Duwamish River was a particular gap in knowledge that was worth addressing. Plant community ecology, including the relative presence of a few key species and amount and type of invasive species, can influence prey availability and refuge area for juvenile salmon. Some sites were created between 10 to 20 years ago, and any detailed vegetation monitoring typically lasts up to a maximum four or five years after site construction and planting (FWS 2004; USACE Monitoring 2005). This research directly addresses this data gap through detailed cataloguing and analysis of intertidal plants species and assemblage at four restored sites.

2.4 Social Perspective and Green Space

From a human health and well-being standpoint, the lack of open green space in the neighborhoods in and around the Lower Duwamish River is problematic (Vision Plan 2014). The benefits of spending time in urban nature have been studied for several decades, and more direct linkages to physical, emotional, and social well-being benefits are beginning to be uncovered (Shanahan et al. 2015). Some positive effects of exposure to green space are direct, such as improved air quality in areas with more trees and vegetation. Others are indirect, such as enabling or encouraging people to exercise more (e.g. walking to and within a small green space), or even restorative, such as reducing the effects of stress (Jackson et al. 2013; Lee et al. 2013; Ratcliffe et al. 2013).

In addition to very low amounts of green or open spaces, the neighborhoods surrounding the LDR, such as the Industrial District and South Park, rank amongst the highest at risk in numerous categories under the Environmental Health Disparities Index (Index) (DOH, WTN n.d.). The Index was developed, roughly, by combining a selection of environmental exposures and effects (e.g. proximity to waste water discharge, diesel emissions, and toxic release facilities) with sensitive populations (e.g. percent elderly, low birth weight) and socioeconomic factors (e.g. percentage of poverty, limited English, and no high school diploma), with 1 being low risk and 10 high risk. It can be conceptualized as “Risk = Threat x Vulnerability”. Given the number of environmental exposures and socioeconomic factors faced in these communities, such as some mentioned above that are not easily addressed, providing more and better access to green space could be a relatively feasible action toward addressing some of these injustices.

What may be more interesting when examining how access to and use of green space can impart well-being benefits, is the idea that individuals' perceptions of these spaces and personal preferences for natural surroundings may influence their ability to receive potential benefits (Hartig et al. 2014). Examples of this might include how perceived safety or a feeling of being welcomed in a particular green space may influence the overall impact of the time spent there. This research attempts to uncover some of the perceptions and preferences of people spending time in small, restored blue-green spaces in the Lower Duwamish, in order to determine if and how site features (e.g. amount of trees, accessibility, and usability) are influencing perceptions and use. In addition, it seeks to understand in what ways and how often people are using the spaces, and to reflect on ways that restoration project design (e.g. intentionally welcoming, size, walkable space) and long term outcomes (e.g. plant compositions, wildlife use, and overall site condition) influence these uses and perceptions.

Subsequently, as individual and community connection to urban restored shoreline sites grows, community belief in the benefits of restoration and vocal support of such projects may be crucial for the ongoing maintenance of existing sites and implementation of future projects (Simenstad et al. 2005).

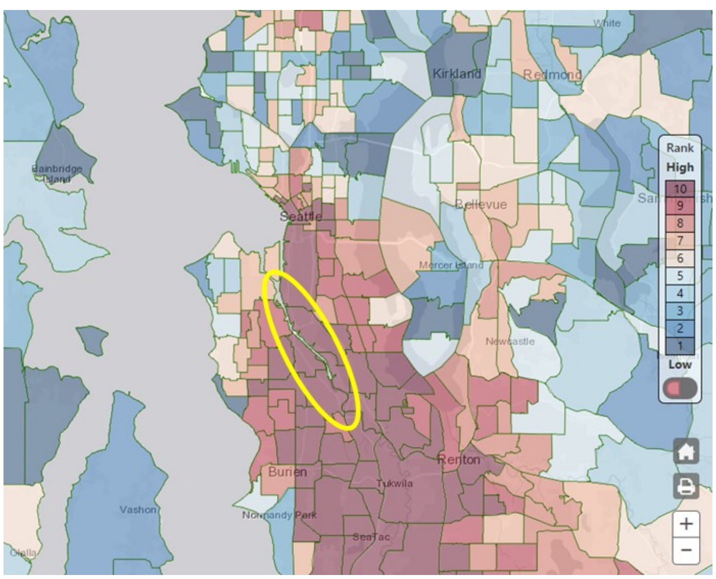


Figure 5: Environmental Health Disparities Index. Dark red = highest; dark blue = lowest.
Approximate Study Area in yellow.

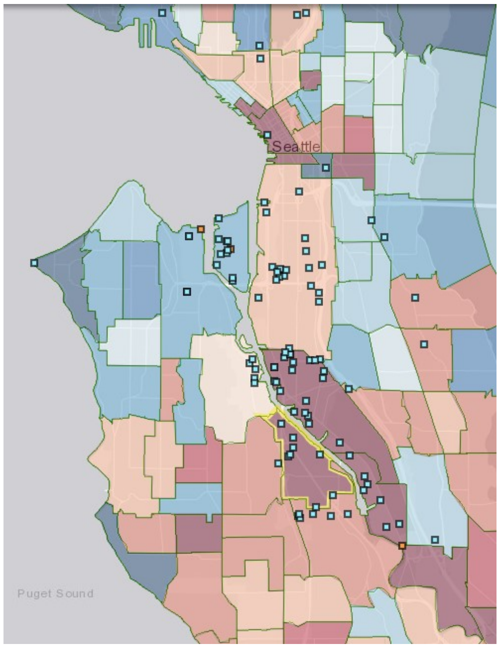
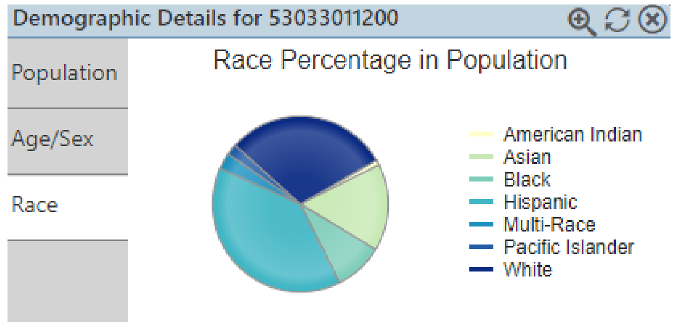


Figure 6 (left): Toxic Release Inventory Sites – illustrates high number of toxic release sites within the study area; South Park census outlined in yellow.

(Figure 5, 6, 7: Taken from DOH Public Health Data, WA Tracking Network. https://fortress.wa.gov/doh/wtn/WTNIBL/)

Figure 7 (below): Demographics of South Park



3 FRAMEWORK

This research employs a social-ecological systems framework and is at the intersection of coastal habitat restoration, human use and values, and justice, and planning. This thesis is a critical reflective analysis of habitat restoration processes and outcomes, and is guided by principles of feminist science.

3.1 Guiding Principles

Throughout the research process, I considered tenents of feminist and anti-colonial science. Greta Gaard describes a feminist methodology as one that "puts the lives of the oppressed at the center of the research question" and "…undertakes studies, [and] gathers data" in order to improve aspects of their lives" (Gaard 2013). Mary O'Brien posits that researchers take a political side simply by asking questions, even if unintentionally (CLEAR lab n.d.). A stance can be taken based on where the researcher chooses to conduct research, by failing to ask certain questions, or by deciding what information to include. My interest in human and justice dimensions of ecological restoration center around this concept, and the importance of understanding the benefits people may experience as a consequence of restoration efforts in urban, under-resourced areas. The research takes a broad view of who or what may be considered oppressed or disadvantaged within and around the study area, from low-income immigrant communities to urban invasive plants.

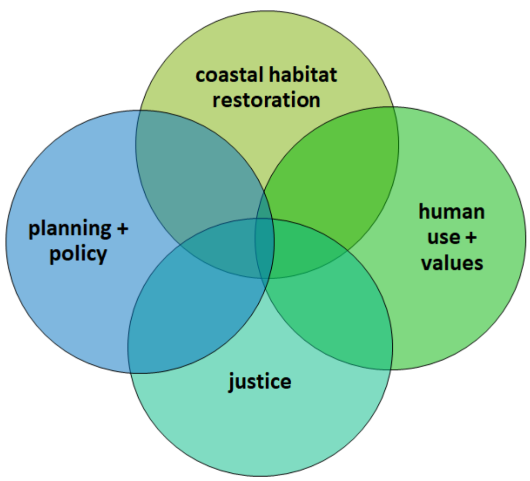
The ecological part of my research, consisting of intertidal plant surveys, takes place in an aquatic habitat in a polluted, developed, urban area. While it is a relatively small study, it falls within two geographies that are poorly represented in the field of ecology: aquatic habitats, and urban areas (Martin et al. 2012), categories less-studied in the field of ecology. Additionally, I collect and consider other forms of information, such as feelings that people have about outcomes of site restoration. I do not give preference to any one type of information over another, and look for opportunities to boost the views and opinions of people whose voices are not often heard in this context. The Duwamish Tribe and many other people working on the river have long-standing local knowledge of varying kinds. My interest in equitable access to green spaces and water, as well as intertidal ecology, influenced the study area selection. The communities adjacent to the Lower Duwamish River face numerous environmental injustices, including more polluted air and higher rates of asthma, inability to eat most of the finfish and shellfish that is or can be harvested from the river due to residual toxins, lower access to and higher distances from green and open spaces, and lower socio-economic status than the rest of Seattle residents.

A critical reflective analysis employs a "what – so what – now what" framework, which I apply to this research and thesis. In this framework, 'what' refers to a rational description of the situation, 'so what' includes considerations of immediate implications, and 'now what' involves some assessment of potential future directions or consequences (Hickman and Palmer 2012).

3.2 Social-Ecological Systems

Marion Glaser et al. (2012) define a social-ecological system as "a complex, adaptive system consisting of a bio-geophysical unit and its associated social actors and institutions." When discussing a social-ecological system or ecosystem in this thesis, the system is conceptualized to include the Lower Duwamish River estuary basin and all of the immediate and adjacent surrounding developed areas, neighborhoods, any other green spaces within these boundaries, and the inhabitants and socio-political factors and institutions making decisions that influence this space. Individual shoreline sites are referred to as habitats, field sites, or study sites, somewhat interchangeably. The term ecosystem is inherently ambiguous unless the boundaries are delineated, and even them, the defined ecosystem is still influenced by factors and processes outside of these largely human-constructed edges. There are of course topographic land features that serve as real and sensible boundaries, such as ridges that determine the direction of snow melt and water flow.

3.3 Intersection of Research Interests



This thesis employs interdisciplinary research and diverse perspectives. My research and interests are at the intersection of coastal habitat restoration, human use and values, and justice. In the discussion, I consider how planning and policy might influence issues within this intersection, engaging with Michelle Garvey and others.

Figure 8: Intersection of thesis research interests, Cori Currier 2019.

4 RESEARCH QUESTIONS

At restored shoreline sites within the Duwamish River Estuary:

Research question 1: What is the current status of intertidal vegetation at four varying shoreline sites, many years after restorative actions and planting?

> Sub-question 1: What are detectable differences and similarities of plant species and assemblages across sites and within tidal zones, and what are some possible implications for use by salmon?

Research question 2: How are people using varying restored urban-industrial shoreline sites, and what factors influence use?

> Sub-question 2: What values and beliefs are contributing to human use and perceptions of these spaces?

Based on a synthesis and reflection on these findings, what are the possible implications for restoration planning and environmental justice?

5 METHODS

5.1 Overview - Case Study with Multiple Methods

This research follows an interdisciplinary case study approach, which allows for freedom and flexibility with the types of data sources that can be incorporated (Thomas 2011). The study area is within a roughly 11 mile stretch of heavily developed estuary spanning the Lower Duwamish River (LDR) and Elliot Bay. This is a single case, of habitat restoration processes and the social-ecological factors influencing and influenced by these processes within the LDR. Within this case and study area, there are multiple embedded sub-units of analysis (Yin 2012) — specifically, separate restored or enhanced shoreline habitat sites. Each study site is contained within the study area, which can be thought of as a nested ecosystem (Berkes 2015) existing within the greater surrounding urban-industrial area and expanding out to the boundaries of the Green-Duwamish watershed. My research focused on six primary study sites, though there are a total of 14 sites from which I draw information. The resulting analysis is a critical reflection of restoration processes within the Lower Duwamish River, how they may or may not be influencing human use, and speculation about changes that could be made to address identified problems.

5.1a. Data Collection Overview:

I used multiple methods to answer my research questions, including both social and ecological primary data collection. Primary data collection methods include: *elite interviews with key informants, participant observation, semi-structured intercept interviews,* and *point intercept plant transects.*

<u>Plants:</u>

Intertidal plant surveys were conducted at four shoreline sites spanning the Lower Duwamish River between river mile 3.9 and 8.6. These sites are South Park Bridge (SP), Hamm Creek, North Wind's Weir (NWW), and Codiga Park. See section 5.3 below for more detail.

Interviews:

Intercept interviews were conducted opportunistically, at the above sites as well as four additional restored sites, which are Olympic Sculpture Park, T-105, T-108, and Duwamish Waterway Park. Sixteen (16) people were interviewed in total, using semi-structured interview methodology. None of the interviewees were recorded. Detailed notes were taken during and after each interview. Additionally, I did several elite interviews with key informants, which were planned in advance and varied in depth and purpose. Two of the elite interviews were recorded.

Naturalist and Participant Observation:

Additionally, I spent ample time at study sites along the river, and made unconstrained naturalist observations and field notes to integrate into the findings and discussion. Some of these were used to create Social-Ecological Site Profiles. On-site interviews were supplemented with participant observation of people using the shorelines within the river, estuary, and bay.

Secondary Data:

Secondary data sources included numerous technical reports and ecological studies of the Duwamish River, including studies focused on juvenile salmon. Literature and background information included a review of diverse perspectives on: ecological and watershed restoration, shoreline armoring, numerous critical takes and writing on the conservation movement in the United States, restoration as a practice, and human well-being as it is influenced by non-human nature or green environments, particularly in urban areas.

5.1b. Data Analysis Overview:

I analyzed the collected plant data using R programming language. The plant data analysis methods are briefly summarized in section 5.4 below. Interview analysis consisted of deductive and exploratory thematic analysis, described in section 5.5. Additional social-ecological observations have been possible while I have been conducting ongoing research on floating wetlands at T105 and T108, for another project. These observations have not been formally analyzed, but have contributed to insights and my ongoing understanding of the relationships people have formed with the Duwamish River. Naturalist and participant observation information were incorporated in a similar fashion, and used to inform the development of social-ecological site profiles.

5.2 Study Site Selection

The main goal in selecting sites was to capture the diversity of habitat types and ecological functions along the river, as well as sites that might serve different communities and provide a range of benefits for people. The following criteria was used to achieve this goal:

Site Selection Criteria:
Restored or enhanced to varying degrees and in different ways
Different ecological functions (e.g. side channel vs. river bank)
Spectrum of public access levels and types
Encompass west and east banks
Spanning as many neighborhoods as possible

Figure 9: Table – Study Site selection criteria, developed based on research goals.

The information about each site was gathered by reviewing technical reports (Duwamish Blueprint 2014) and by visiting all potential sites over several days and tidal levels. The following is a brief, generalized guide that I developed for multi-site selection when conducted geographically or spatially oriented research. This methodology could be employed by anyone wishing to conduct similar multi-unit case study research and analysis.

Site Scoping Methodology:

Step 1: Identify criteria of interest, that is, what factors do you care about or might you want to consider in the analysis? Determine how much variety you want within or among sites, and whether or not you’re going to need control sites.

Step 2: Review any available background information on individual sites and the study area as a whole. Talk to any potential site experts. Decide which sites to visit.

Step 3: Take detailed field notes of each site. Consider making sketches that include the site and surrounding conditions.

Step 4: Create a table of sites of interest that summarizes the characteristics or factors of interest. For instance: amount of armor removed, number of acres planted, accessibility, type of water access, demographics.

Step 5: Select study sites using the table generated as a guide.

Primary Study Sites

Six primary study sites were selected, though I spent time at a total of 14 sites and consider social-ecological observations from all locations visited to be applicable to this thesis.

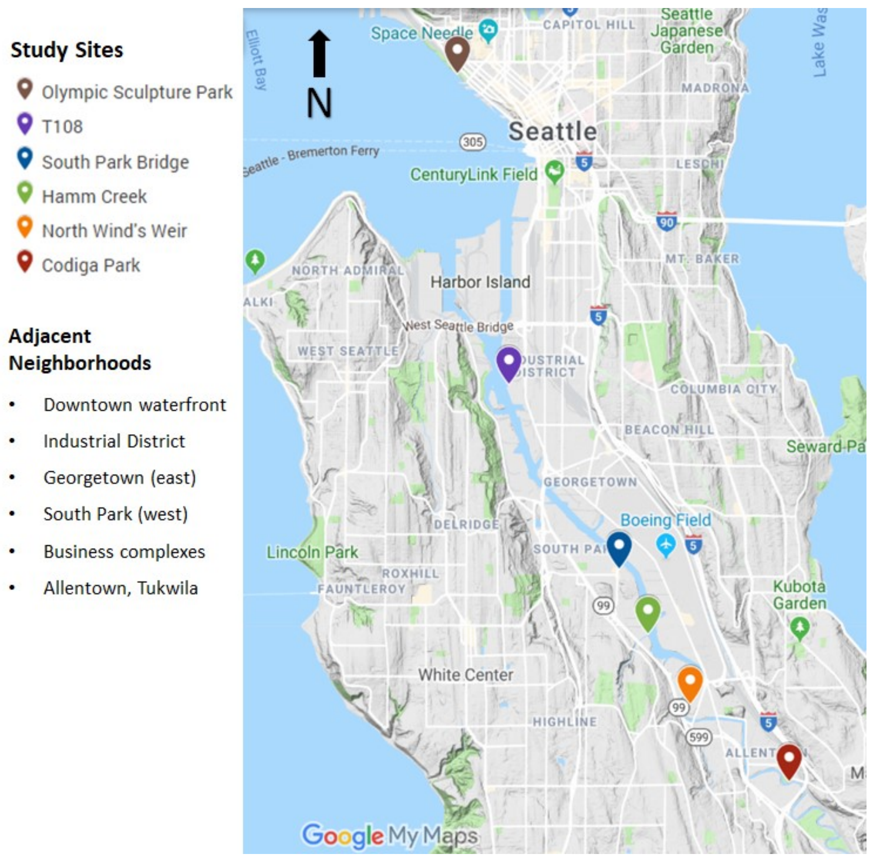


Figure 10: Map of study sites in case study area, and adjacent neighborhoods. King County, Washington. Made with Google My Maps, by Cori Currier.

The sites span neighborhoods with different demographics, including the Industrial District, South Park, Georgetown, unincorporated parts of King County, Allentown, and Tukwila. Olympic Sculpture Park in downtown Seattle and Codiga Park are the only sites where shoreline is intended for use by people. Each field study site is conceptualized to include the adjacent built and natural surroundings, upland area, the intertidal zone, and the river. The Duwamish Blueprint 2014 was used as a primary resource for understanding details of past restoration work when selecting potential sites. It is an excellent model for agencies and groups planning restoration projects within similar high-use, highly developed and armored coastal areas.

The goal in selecting which sites to include in the study was to capture the spectrum of social and ecological functions of restored habitats along the river, so that selected study sites would be relatively representative of the study area. The six primary sites selected, from north to south, include: Olympic Sculpture Park, Terminal 108, South Park Bridge, Hamm Creek, North Wind's Weir, and Codiga Park. I included the Olympic Sculpture Park in Elliott Bay as an example of a highly visible and more touristic location, as well as a potential point of contrast to the other lesser known sites.

5.3 Plant Methodology

Species Identification:

A few days were spent with three experienced botanists: Van Bobbit, Sandy Bowman, and Dan Paquette at created and vegetated Duwamish River shoreline sites, identifying and cataloguing common riparian and intertidal plant species. Photos, samples, and field notes were used to record identified species. Lists were created from these species and used as a guide when conducting point-intercept transect surveys (or "plant surveys"). Additionally, existing plant lists were generated from monitoring reports (USACE Monitoring 2005) and were used to supplement and cross reference the plants that were identified in the field.

Plant Surveys:

Four restored shoreline sites were surveyed, in the intertidal zone. From north to south along the river, the sites are: South Park Bridge, Hamm Creek, North Wind's Weir, and Codiga Park. See figures in section 6.4c for approximate plant survey locations at three of the sites. The South Park plant survey, not pictured in this section, was conducted below the bridge. Intertidal vegetation surveys were conducted by teams of two people, which included myself and a different field assistant at each site.

Plant survey methodology was based on protocols of point-intercept transects, including the point-hit method to capture layers of vegetation from head height (max) to the ground (University of

Idaho, n.d.). To capture plants spanning all tidal zones, and a representative sampling of species present, we collected data along evenly-spaced transects running perpendicular to the shoreline. Transects were done using a tape measure and began upland at the ordinary high water mark (OHWM), which was estimated based on ground condition and plants present. Transects were spaced 2 meters apart so as to best avoid capturing any individual plant within more than one transect. Seven (7) transects were completed at three of the sites, and 10 transects were done at one site. This was primarily because we were only able to survey a maximum of seven (7) transects at any given site within the low-mid tide window on a single day, and time in the field was limited to five (5) days due to logistic constraints.

We marked 30 intercept points per transect at 40 cm (0.4 m) intervals along the tape measure, resulting in 11.6 meter transects. Up to 4 vertical layers of plants were identified at each point. See the sketch below for an illustration of this method. In most instances, there were no more than four species present at any given point. Plants were recorded only when a part of the plant was touching a straight vertical line extending from the highest plant to the ground. The highest layer of vegetation was recorded as layer 4; the ground was layer 1. There were instances in which all four layers were the same species, for instance, when a point landed in an area dominated by planted bulrush. The ground-type was recorded (e.g. mud, rock, sand) but was only indirectly used in the statistical analysis when calculating coverage metrics.

<u>Post-field sample identification</u>

Many plants were able to be identified in the field, while conducting surveys. For those plants that could not be identified to the species level on site, photos were taken and small physical samples were collected in labeled envelopes for post-field identification. Identification of several samples was conducted by an experienced botanist, Dan Paquette.

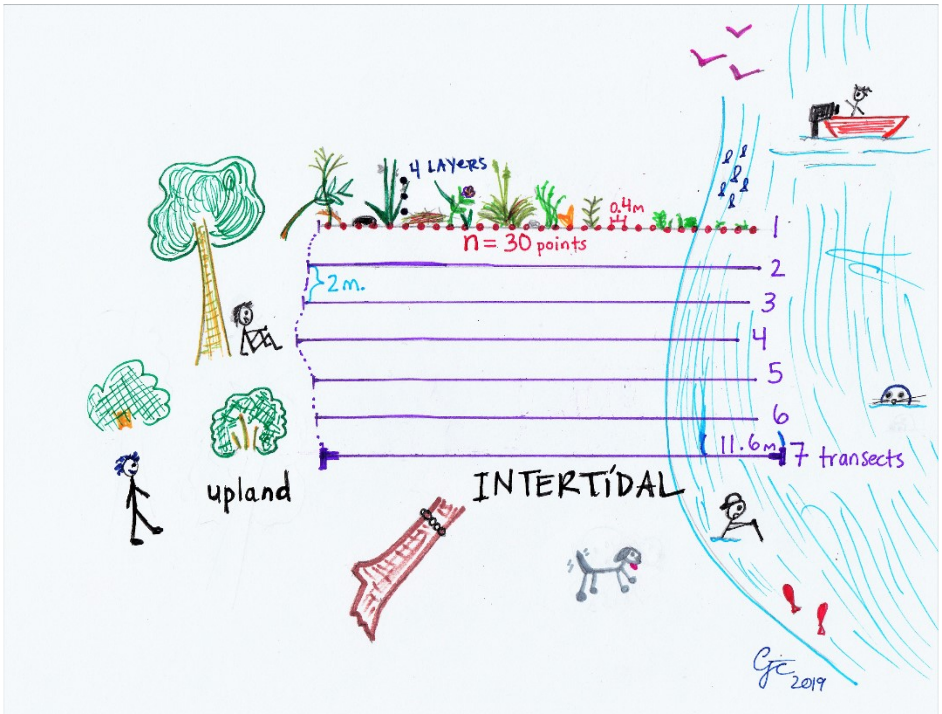


Figure 11: Sketch of a representative field site with an illustration of plant survey methods. Cori Currier, 2019.

5.4 Plant Analyses in R

Statistical analysis was done using R programming language in R Studio. Under direction and in collaboration with Cori Currier, Devon Penney authored the R code for the following functions: Bray-Curtis Dissimilarity, Rarefaction, Biodiversity, and Contours.

5.5 Interview Methodology

Semi-Structured Intercept Interviews

For the purpose of this thesis, and interview is defined as "an intimate, intentional, and systematic interaction in which a researcher seeks to gain information about the knowledge, feelings, attitudes, and behaviors of others, in order to uncover something closer to the truth" (Currier 2018).

An "intercept" interview refers to speaking with people who happened to be spending time at restored shoreline sites within the study area, and whom were willing to talk and answer questions. These shoreline interviews followed a semi-structured approach. Semi-structured interviews attempt to achieve a middle ground, between a survey and something completely open-ended. As Leech 20002 describes, they "can provide detail, depth, and an insider's perspective, while at the same time allowing hypothesis testing and quantitative analysis". When interviewing someone, especially an un-suspecting local, it is important to gain consent, and to consider the opening and order of questioning. Gaining rapport is crucial, so starting out casually and easing into simple questions can be an effective approach. Question order is also important for "substantive reasons". Once consent was received and some rapport established, I began by simply asking the participant to talk about a typical visit.

In the intercept interviews, I sought to uncover (either indirectly or directly) factors influencing use, and specific personal preferences. This particular component of the research could be considered partly deductive, as I was curious about preconceived notions or ideas about what might influence use and perceptions of the sites. I developed the below list of potential factors from my own curiosity and conversations with others. The list was incorporated into the potential list of interview questions, which I held on hand for reference but did not show participants directly.

Most participants were not explicitly/verbally presented with this list; some who needed more prompting were asked these questions explicitly. Some of these factors were explicitly mentioned by interviewees without prompting, or when asked if there was anything in particular that they liked about the space. Other factors were determined to be driving use based on other information gathered in the interviews. For instance, if an interviewee used the word 'beach' to describe what they liked about a site, they would receive a check mark next to category 'A', 'a natural looking or soft shoreline'.

Detailed notes were taken during and after each interview and the quotes included here are drawn from those handwritten notes. All participants wished to not be recorded electronically. All intercept interview data was reviewed and analyzed for key themes. Findings were separated by categories of use, types of use at each site, and by factors influencing use across sites.

<u>Elite Interviews with Key Informants</u>

An elite interview is defined as "an unstructured, but strategic interaction in which the interviewee is treated as a specialist of the topic and/or area of interest" (Currier 2018). Key informants were selected using five criteria, developed by Tremblay, 1957. These criteria are: their role in the community (the only factor that can be known in advance), their knowledge or access to information (and ideally "meaningful absorption of information"), willingness to communicate openly, communicability, and impartiality. Impartiality implies that the interviewer should be aware of potential biases so that "their effects can be properly appraised" (Tremblay 1957, p. 692-3). Following the advice of Dexter, 1970, on whom to see first, I began the elite interviews early in the research process, seeking to talk to experts within the field study area (Lower Duwamish) and those with detailed local knowledge of the restoration efforts over the years. As Dexter so eloquently put it, *"…I want intelligent, judicious people know the way things are really done, not just the way they are supposed to be done, who have been around for long enough to have some sense of the history of the situation… and… who like to think in comparative and abstract terms."* I was fortunate to speak with many people who fit this description.

The combination of key informants, other interviewees, and background research information enabled me to conduct a multiple perspective analysis (Dunn 2018), as information gathered included technical, scientific, and personal perspectives from an "inter-paradigmatic mix". This "mix" included Duwamish tribe representatives, agency leads (NOAA), industry (Boeing), commercial, local activists, community members, shoreline users, an artist, non-profit managers (DRCC), and fisheries and wetland scientists. Information gathered from the elite interviews was used to support decisions about research design, and to inform my arguments. Two elite interviews were recorded with permission, and transcribed.

A note on approach: During the interviews, the goal was to get and keep the person talking more than it was to follow a strict questioning format. Prompts were used only as needed. For instance, if an interviewee responded to "tell me about a typical visit" with only a brief "I usually just come to sit and relax"; I would follow up, to try to elicit things they see and feel. From there, they might start mention hoping to see interesting wildlife, or hoping to see Rainier in the distance, or feeling less worried.

6 FINDINGS AND DISCUSSION

Organization:

6.1 Plant Findings
6.2 Plant Discussion
6.3 Social Findings and Discussion
6.4 Synthesis and Discussion

6.1 Plant Findings

There was a combined total of 978 plant observations; the term point and observation are used interchangeably. A total of 64 different species, (including those that were partially or completely unidentified—TBD or "unknown"—but determined to be unique species), were observed across all four study sites. North Wind's Weir (NWW) had 27 species, Codiga Park had 25 species, Hamm Creek had 20 species, and South Park Bridge (SP) had 14 species. We were able to identify about 94.6% of plant observations to the species level.

<u>Summary of plant categories (designations) by number:</u>

NATIVE: 31 species, 624 observations; **INTRODUCED**: 18 species, 301 observations

Unknown: 15 species*, 53 observations

**Unidentified species account for 5.4% of all plant observations. The majority of the unknown species included grasses determined to have been tracked in (as opposed to intentionally planted), a few instances of rushes that were identified to Genus level, and a few one-time observed weedy plants that were likely not planted as part of the restoration efforts.*

Not including the unknown plants, there were 2.07 native plant observations for every 1 introduced (non-native) plant. Put another way, roughly one third (1/3) of the plant observations were of introduced species. This number is likely slightly higher, as it is estimated that many, though not all, of the unknown species were introduced. Note that the number of plant point observations is a great way to represent the species present and their locations, but is not the same as volume of plants. This study was not concerned with volume or total biomass of plants.

The first graph shows the name and frequency of all 64 species observed across all four sites. Each bar represents a single species along the y axis, with the total number of point observations of each species on the x axis. Green is native, blue is introduced, red is unknown.

Intertidal Plant Species at Four Restored Urban Shorelines – Lower Duwamish River 2018

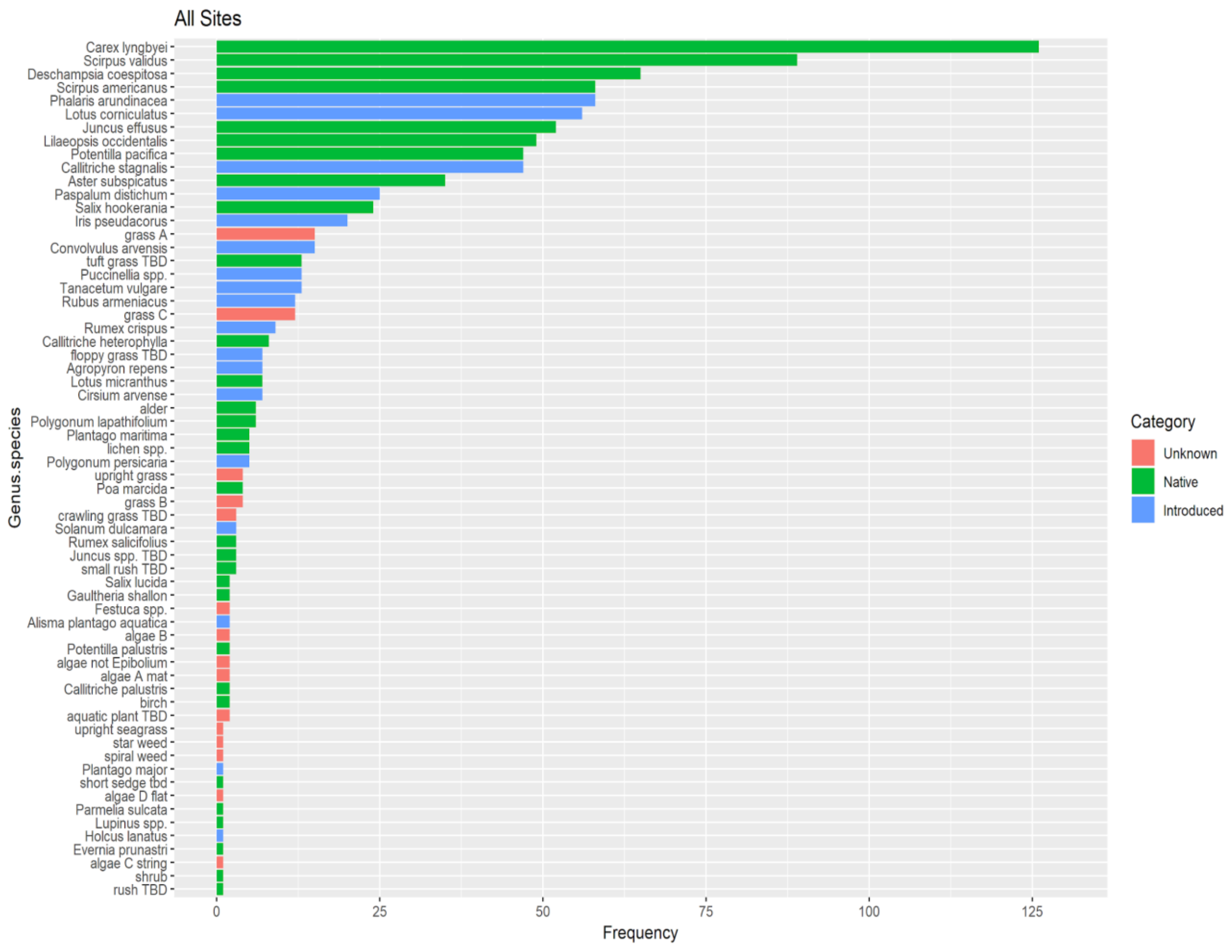


Figure 12: Complete list of species and their frequency (number of point observations) across all sites. *TBD = to be determined

<u>Intertidal Plant Species by Site</u>

Each site was treated as a unit of analysis. The plant species found at each site, the frequency or number of observations of each species, and their categorization are listed in the tables and visualized in the graphs below.

Site Tables

The four tables below include scientific and common names of all observed species at each site, and are organized by descending frequency within the categories of native, introduced, and unknown (or unsure). Categorizations by color include: native (green), introduced (blue), or unknown (red); as well as those introduced species that are also on the Washington noxious weed list (yellow). Lastly, purple is used to indicate species that occur at other sites within the study, and the percent as compared to the total number of observations of that species across all sites is listed in the final column.

South Park - Intertidal Plants

Native or Introduced	**WA Noxious**	***Genus species*** ***= incomplete ID**	**Common name**	**# obsv.**	**total # obsv. across sites**	**% of total obsv.**
Nat	-	*Scirpus americanus*	American bulrush	58	58	100
Nat	-	*Aster subspicatus*	Douglas aster	9	35	26
Nat	-	*Gaultheria shallon*	salal berry shrub	2	2	100
Nat	-	*Salix lucida*	Pacific willow	2	2	100
Nat	-	short sedge tbd*	unknown short sedge	1	1	100
Int	yes	*Convolvulus arvensis*	field bindweed	13	15	87
Int	no	*Agropyron repens*	couch grass, quack grass	7	7	100
Int	no	*Puccinellia spp.**	unknown salt grass	5	5	100
Int	no	*Rumex crispus*	curly dock	3	9	33
Int	no	*Alisma plantago aquatica*	European water plantain	2	2	100
?	-	crawling grass TBD*	unknown crawling grass	3	3	100
?	-	algae B*	unknown algae B	2	2	100
?	-	*Festuca spp.**	unknown fescue	2	2	100
?	-	algae D flat*	unknown seaweed (algae D)	1	1	100
		14 species	**total # plant observations**	**110**		

Figure 13.1 South Park - Intertidal Plants

Photo (left): South Park Bridge site, facing southwest at the shoreline. CJC

Hamm Creek - Intertidal Plants

Native or Introduced	WA Noxious	*Genus species* *= incomplete ID	Common name	# obsv.	total # obsv. across sites	% of total obsv.
Nat	-	*Carex lyngbyei*	Lyngbye's sedge	88	126	70
Nat	-	*Aster subspicatus*	Douglas aster	24	35	69
Nat	-	*Scirpus validus*	soft stem bulrush	23	89	26
Nat	-	*Deschampsia coespitosa*	tufted hair grass	20	65	31
Nat	-	*Potentilla pacifica*	Pacific silverweed	19	47	40
Nat	-	*Salix hookerania*	Hooker's willow	19	24	79
Nat	-	tuft grass TBD*	unknown tuft grass	13	13	100
Nat	-	*Alnus rubra*	red alder	6	6	100
Nat	-	*Plantago maritima*	sea plantain	5	5	100
Nat	-	*Lotus micranthus*	desert deervetch	2	7	29
Nat	-	*Juncus spp.* TBD*	unknown Juncus	1	1	100
Int	yes	*Iris pseudacorus*	yellow flag iris	9	20	45
Int	yes	*Phalaris arundinacea*	reed canary grass	9	58	16
Int	no	*Rubus armeniacus*	Himalayan Blackberry	8	12	67
Int	?	floppy grass TBD	unknown floppy grass	7	7	100
Int	no	*Plantago major*	common plantain	1	1	100
?	-	upright grass*	unknown upright grass	4	4	100
?	-	spiral weed*	unknown spiral weed	1	1	100
?	-	star weed*	unknown star weed	1	1	100
?	-	upright seagrass*	unknown upright seagrass	1	1	100
		20 species	**total # plant observations**	**261**		

Figure 13.2 Hamm Creek Intertidal Plants

Photo (left): Hamm Creek channel and marsh at high tide. Area pictured is a mud flat at low tides. Photo by CJC.

North Wind's Weir - Intertidal Plants

Native or Introduced	WA Noxious	*Genus species* *= incomplete ID	Common name	# obsv.	total # obs. across sites	% of total obs.
Nat	-	*Deschampsia coespitosa*	tufted hair grass	45	65	69
Nat	-	*Lilaeopsis occidentalis*	western grasswort	42	49	86
Nat	-	*Carex lyngbyei*	Lyngbye's sedge	38	126	30
Nat	-	*Scirpus validus*	soft stem bulrush	31	89	35
Nat	-	*Potentilla pacifica*	Pacific silverweed	18	47	38
Nat	-	lichen spp.	lichen	5	5	100
Nat	-	*Lotus micranthus*	desert deervetch	5	7	71
Nat	-	*Poa marcida*	withered bluegrass	4	4	100
Nat	-	*Juncus effusus*	soft/common rush	3	52	6
Nat	-	*Rumex salicifolius*	willow dock	3	3	100
Nat	-	*Aster subspicatus*	Douglas aster	2	35	6
Nat	-	*Juncus spp.* TBD*	unknown *Juncus spp.*	2	2	100
Nat	-	*Potentilla palustris*	purple marshlocks	2	2	100
Nat	-	*Evernia prunastri*	ring lichen	1	1	100
Nat	-	*Lupinus spp.**	unknown lupine	1	1	100
Nat	-	*Parmelia sulcata*	shield lichen	1	1	100
Int	no	*Paspalum distichum*	knot grass	25	25	100
Int	yes	*Phalaris arundinacea*	reed canary grass	10	58	17
Int	no	*Puccinellia spp.*	unknown salt grass	8	8	100
Int	yes	*Cirsium arvense*	Canada thistle	7	7	100
Int	no	*Rumex crispus*	curly dock	4	9	44
Int	yes	*Iris pseudacorus*	yellow flag iris	3	20	15
Int	no	*Solanum dulcamara*	climbing nightshade	3	3	100
Int	no	*Holcus lanatus*	velvet grass	1	1	100
?	no	algae A mat*	unknown algae A	2	2	100
?	no	algae X not epibolium*	unknown algae X	2	2	100
?	no	algae C string*	unknown algae C	1	1	100
		27 species	**total # plant observations**	**269**		

Figure 13.3 NWW Intertidal Plants

Codiga Park - Intertidal Plants

Native or Introduced	WA Noxious	***Genus species*** ***= incomplete ID**	**Common name**	**# obsv.**	**total # obsv. across sites**	**% of total obsv.**
Nat	-	*Juncus effusus*	soft/common rush	49	52	94
Nat	-	*Scirpus validus*	soft stem bulrush	35	89	39
Nat	-	*Potentilla pacifica*	Pacific silverweed	10	47	21
Nat	-	*Callitriche heterophylla*	two-headed water starwort	8	8	100
Nat	-	*Lilaeopsis occidentalis*	western grasswort	7	49	14
Nat	-	*Polygonum lapathifolium*	curlytop knotweed	6	6	100
Nat	-	*Salix hookerania*	Hooker's willow	5	24	21
Nat	-	small rush TBD*	unknown rush	3	3	100
Nat	-	birch	birch	2	2	100
Nat	-	*Callitriche palustris*	vernal starwort	2	2	100
Nat	-	rush TBD*	unknown rush	1	1	100
Nat	-	shrub*	shrub	1	1	100
Int	no	*Lotus corniculatus*	birdsfoot trefoil	56	56	100
Int	no	*Callitriche stagnalis*	pond water-starwort	47	47	100
Int	yes	*Phalaris arundinacea*	reed canary grass	39	58	67
Int	yes	*Tanacetum vulgare*	common tansy	13	13	100
Int	yes	*Iris pseudacorus*	yellow flag iris	8	20	40
Int	no	*Polygonum persicaria*	spotted lady's thumb	5	5	100
Int	no	*Rubus armeniacus*	Himalayan Blackberry	4	12	33
Int	yes	*Convolvulus arvensis*	field bindweed	2	15	13
Int	no	*Rumex crispus*	curly dock	2	9	22
?	?	grass A*	unknown grass A	15	15	100
?	?	grass C*	unknown grass C	12	12	100
?	?	grass B*	unknown grass B	4	4	100
?	no	aquatic plant TBD*	unknown aquatic plant	2	2	100
		25 species	**total # plant observations**	**338**		

Figure 13.4 Codiga Park Intertidal Plants

Richness and Frequency

Graphs 13.1 – 13.4 below illustrate the type and number of species present, or species richness, and the frequency of each species (or number of point observations - approximate abundance) at each site. The information is the same as what is presented in the above tables. These graphs are used to illustrate and assess similarities and differences across sites. Colors indicate their classification as native, introduced, or unknown.

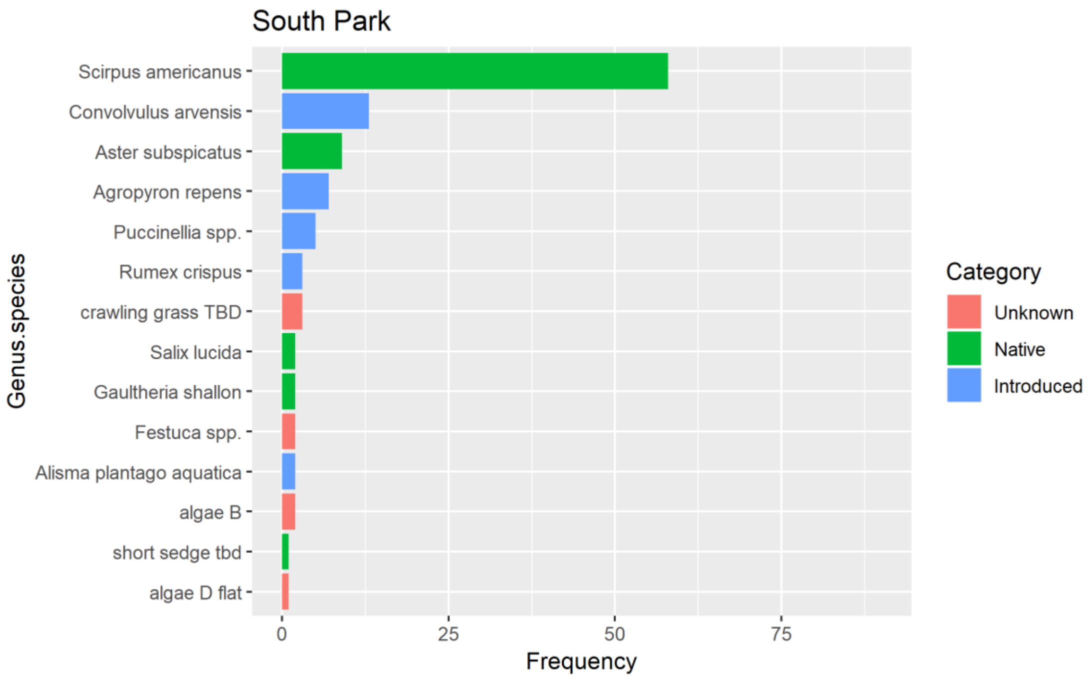


Figure 14.1 (above) South Park intertidal plant species, frequency, and category. **Richness: 14**

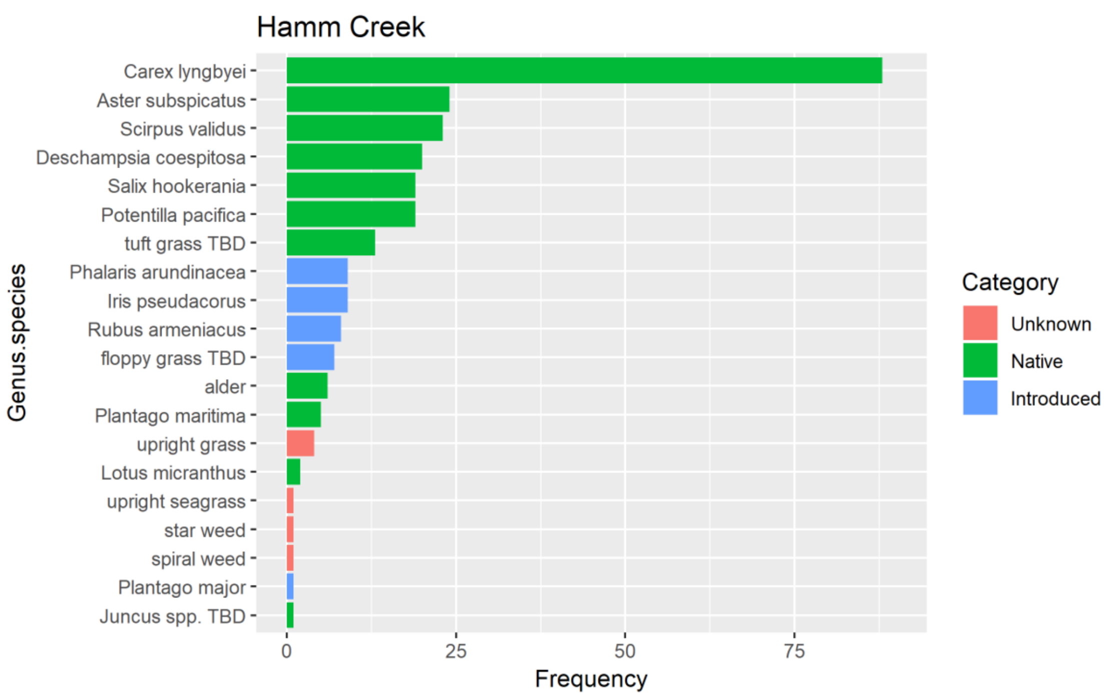


Figure 14.2 (above) Hamm Creek intertidal plant species, frequency, and category. **Richness: 20**

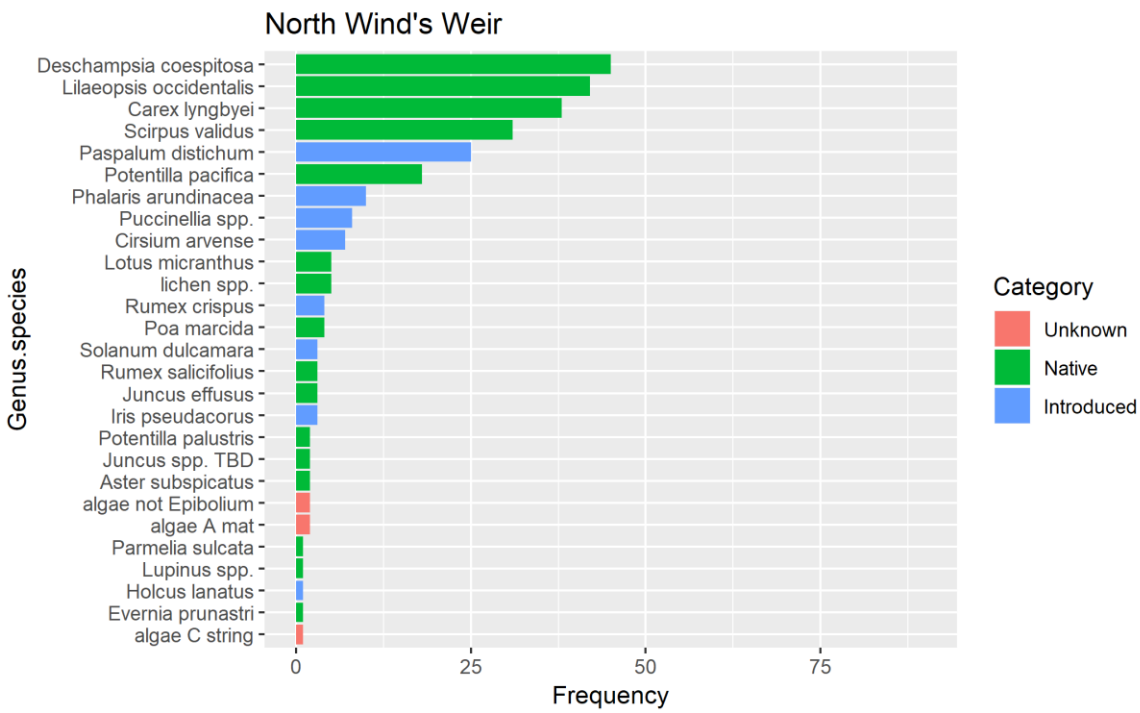


Figure 14.3 (above) NWW intertidal plant species, frequency, and category. **Richness: 27**

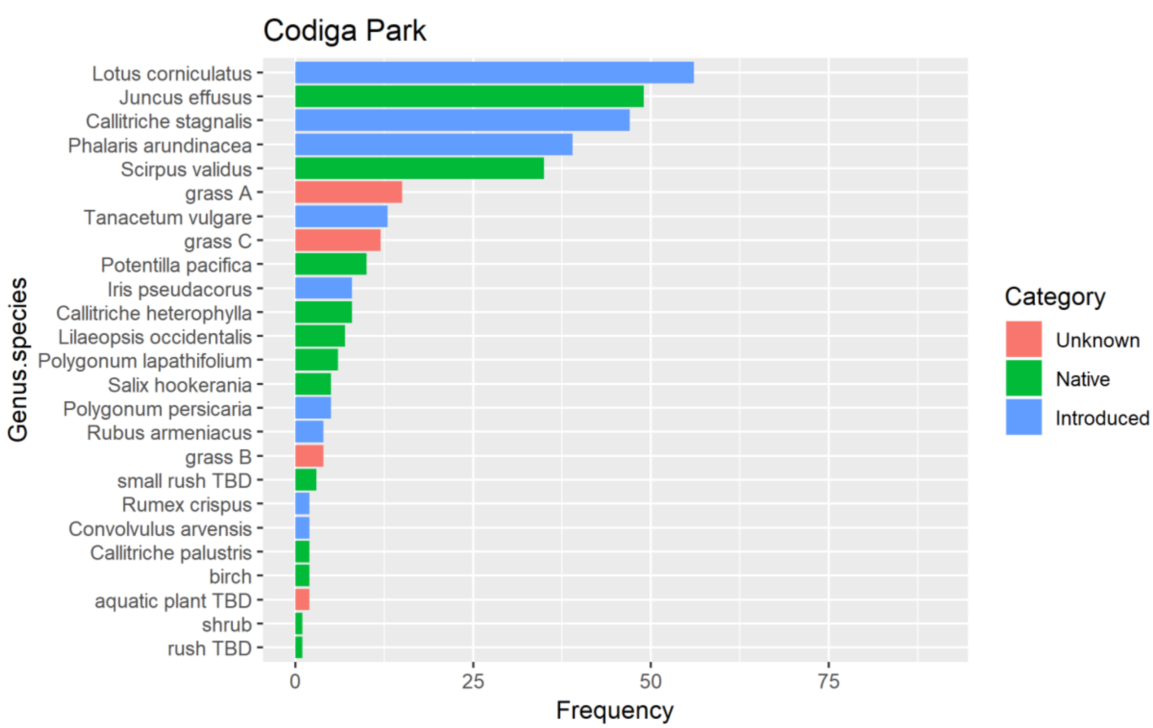


Figure 14.4 (above) Codiga Park intertidal plant species, frequency, and category. **Richness: 25**

Site Dissimilarity Indices

Bray-Curtis dissimilarity indices were calculated between all sites. The index is on a scale of 0 to 1, where a value of 0 would mean the two sites are exactly identical in species present and species distributions. A value of 1 means the two sites are 100% dissimilar, or that no two plants are alike. Site dissimilarity indices amongst sites: NWW to Hamm: 0.56; NWW to Codiga: 0.78; Hamm to Codiga: 0.80; NWW to South Park: 0.95; Hamm to South Park: 0.95; Codiga to South Park: 0.98

	Codiga	**NWW**	**SP**	Hamm
Codiga	0	-	-	-
NWW	0.78	0	-	-
SP	**0.98**	0.95	0	-
Hamm	0.80	**0.56**	0.95	0

Figure 15: Bray-Curtis site dissimilarity indices table

NWW and Hamm are the most similar to one another by a fairly large margin (0.56). South Park and Codiga are the least similar, with almost no overlap (0.98). This is true between South Park and the two other sites (0.95). Codiga is about as similar to Hamm (0.80) as it is to NWW (0.78).

Simpson Biodiversity Indices

The biodiversity (BD) index at each site is calculated between 0 and 1; a value of 0 indicates no diversity. This would mean that there is only 1 species present, i.e., 100% chance of choosing the same species when selecting two species at random from the whole site. A value of 1 would mean that there is no chance of picking the same species when selecting two species at random from the whole site, and values close to 1 indicate very high biodiversity, implying relatively even distributions (number of occurrences) of each species. The relative frequencies of each plant species, combined, makes up the distribution. Diversity is calculated based on the richness and evenness of species distributions at each site. An evenly distributed site would mean that the frequencies (abundance, i.e., number of individuals) of each species are the same.

Site	Biodiversity Index	Richness	# plant observations
South Park Bridge	0.698	14	110
Hamm Creek	0.849	20	261
North Wind's	0.900	27	269
Codiga Park*	0.902	25	338

Figure 16: Table— Biodiversity Index, total number of species, and the total number of plant observations at each site. *Note, 10 transects at Codiga v. seven (7) at other sites

Contours - Tidal Zones

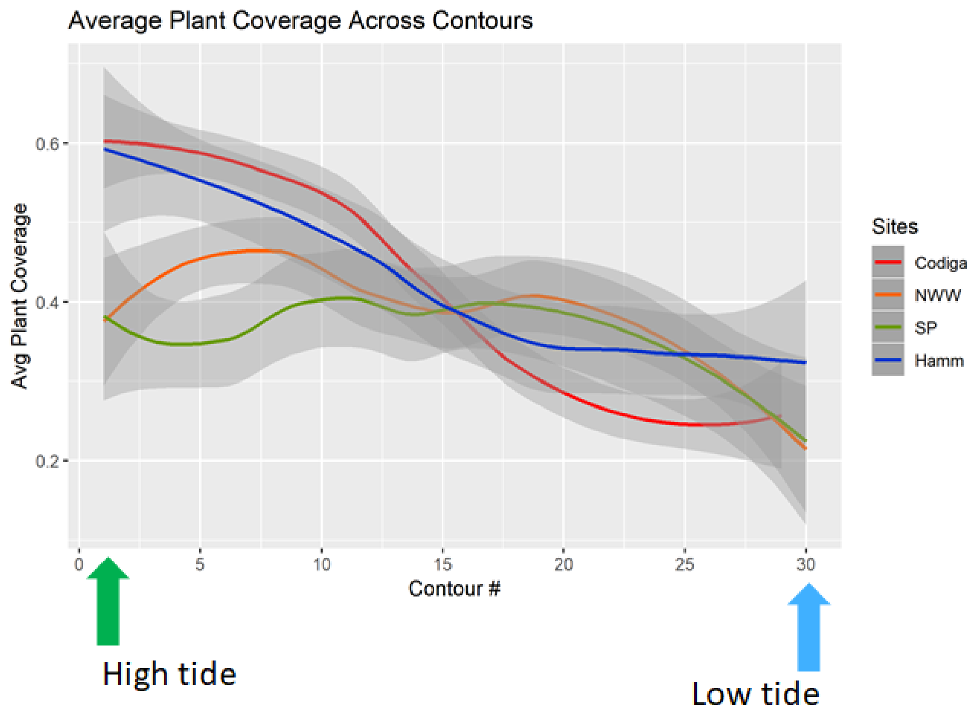


Figure 17: Average plant coverage across contours Points are fit to a line, grey bars show variance.

The contour line analysis enables comparisons of the plant coverage and number of species occurring in high, mid, and low tide zones. Contours run parallel to shore within all tidal zones. The x axis shows average plant coverage across contours. We define a contour as the set of sample points all with the same distance to the high tide line. Additionally, coverage is defined as the total number of plants observed at a given sample point, i.e., the number of plant layers from 0 to 4 occurring at each point. Each point on the graph represents the averaging of total plant coverage for all points on a given contour; points are smoothed for easier interpretation. A discussion of comparisons of these contours is below. Additional analysis could be done to look at individual species, if desired.

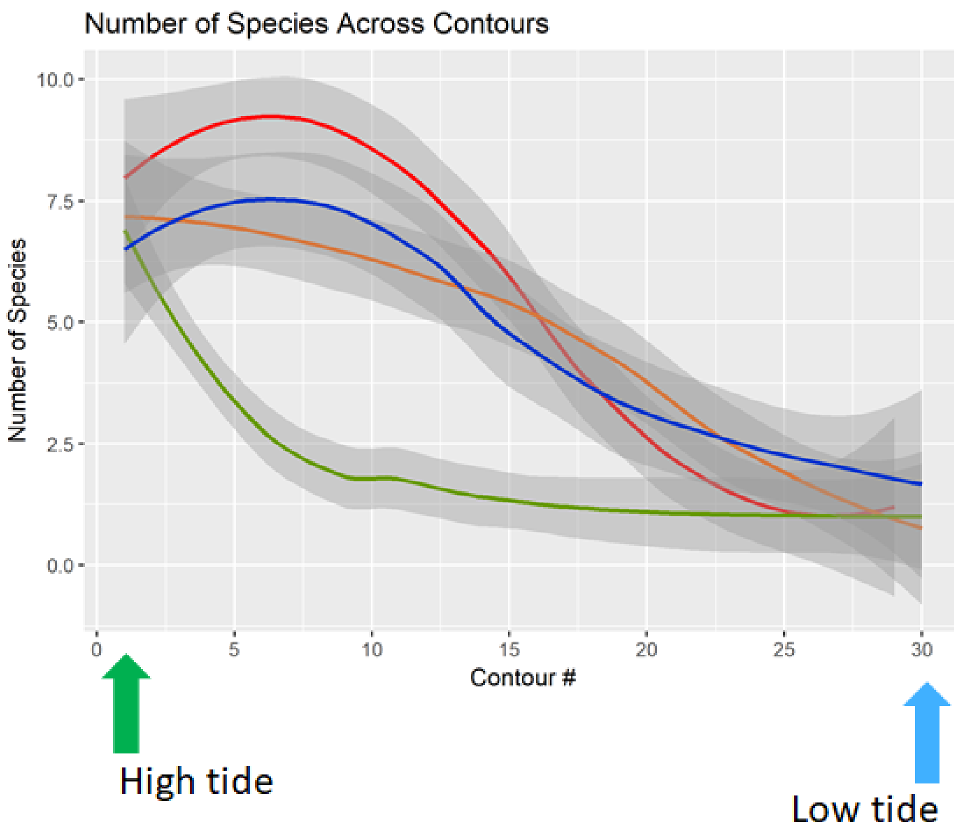


Figure 18: Number of species across contours

6.2 Plant Discussion

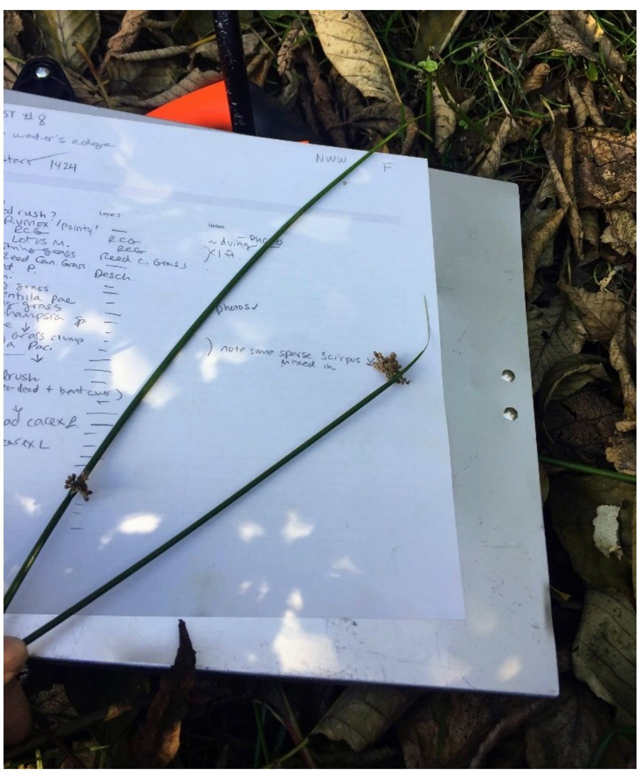


Photo (above): Data collection sheet and sample at North Wind's. By CJC.

Some components of this discussion consider site history, location, conditions, and parameters as they may or may not influence plant species and composition. There were 64 unique species present across sites. The number of point observations, or frequency of each species, is fairly representative of the actual abundances, or number of individuals, found within the transect area and across the site in the intertidal zone.

Rarefaction

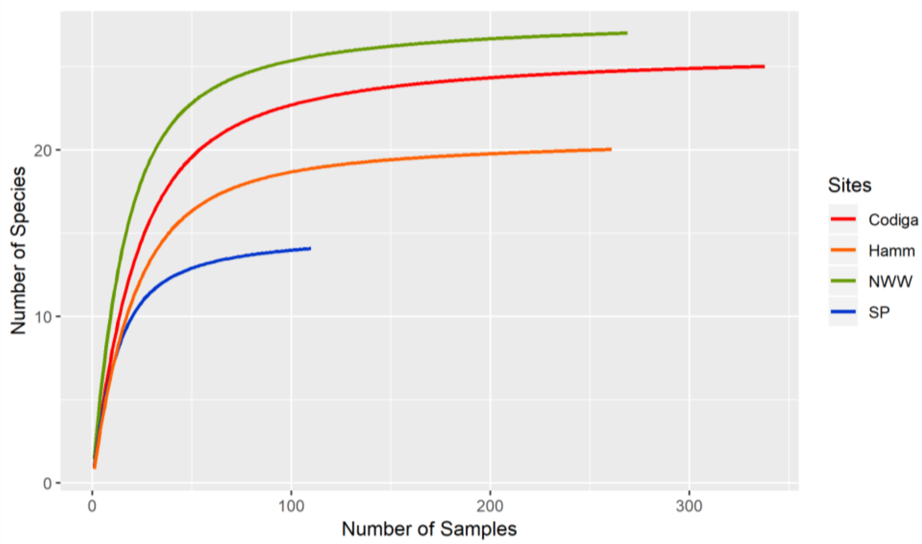


Figure 19: Rarefaction curves of all sites

Rarefaction curves take the distribution of observed plant species for a given site, and computes the expected number of species present for different numbers of plant samples. One would want to see this curve level out with slope approaching zero as the number of samples approaches the true sample count. This is because if the curve asymptotically approaches the field-sampled diversity, then we can conclude we have obtained enough samples to accurately describe the found distribution. Given the distribution of the plants observed across all sites, rarefaction shows that enough samples of plants were taken to accurately represent the relative distributions. This implies we can confidently compare the distributions between sites with metrics such as the dissimilarity index as described below.

Plant Composition

Interestingly, at both South Park (SP) and Hamm, there is a single species that is dominant: *Scirpus americanus* at SP and *Carex lyngbyei* at Hamm. These are two species intentionally planted in restoration efforts, and their spatial distributions ranged mostly in mid tidal zones. While highly skewed plant community assemblages are common in natural salt marshes (Wilco 2011), these two sites are much more skewed than NWW and Codiga. The main difference to note between SP and Hamm are the higher plant occurrences overall at Hamm Creek, and the very similar frequencies of the next top five species Hamm, which are all native, and include *Aster spp., Scirpus spp., and Deschampsia spp.* The latter two were likely planted, while the former (Douglas aster) may have grown in on its own over time. This combination of planted and naturally occurring and/or tracked in species is representative of a novel, or perhaps hybrid habitat, which is a worthy goal in an area such as the Lower Duwamish. Despite presence of some introduced and/or noxious weed species, each site has at least one or two key species (and in most cases more) likely planted as part of the original restoration. Going back to South Park, the size or horizontal distance of the intertidal zone is much narrower than other sites, and it receives much less sun than other sites, as it is located under the bridge. This may be partly contributing to its relatively low species richness and abundance. However, it is likely the least used or accessed by people, though most proximal to a developed area (the town, bridge, and marina). It shows somewhat high instance of introduced species, including *Convovulus* (bind weed) and *Agropyron repens*

The dominant plant at three of the four sites (excluding Codiga) is a native wetland species, intentionally-planted during restoration. Codiga may have the highest amount of human use in the area surveyed, as it was at a publicly accessible park and the survey was conducted on the beach/bank slope along the river, most easily accessible by people. Codiga has many more species, and a higher total plant volume than any other site. However, Codiga is somewhat dominated by introduced or invasive plants, including *Lotus corniculatus (1st),Callitriche stagnalis (3rd), and Phalaris arundinacea (*reed canary grass)*(4th).* Lotus occurred in the mid-upper tidal zones, and often wound around other plants like rushes and other tall species present.

North Wind's Weir is the largest site and has the highest richness and abundance the most plants. It has the least skewed distribution where the top five species occur at relatively high and similar frequencies. Similar to Hamm, NWW is dominated by some intentionally planted, native mid-tidal species, like *Carex, Scirpus, and Decshampsia*. *Lillaeopsis* occurring at NWW was present in fairly high density within the mud flat/low tide zone, where the other plants abruptly stop. It does not appear that emergent or naturally occurring (non-planted) marsh species are growing within the mud flat. Goose enclosure fences may be negatively impacting some plant growth, as the plants within these enclosures were in poor condition, in some cases. However, NWW may empirically be doing the best, as measured by abundance of native and intentionally planted species. From a salmon perspective, this site may be optimal transition zone habitat as compared to the others, though this assessment is mostly based on overall plant assemblage, the width of the opening, with wide being best (J. Cordell, personal communication) and largest total mud flat area, as estimated visually.

Contours - Tidal Zones

We define a contour as the set of sample points all with the same distance to the high tide line. The contour spans all transects and there are 30 contours at each site. However, the plots we show have a smoothed curve fit to them, in order to better show the trends in the data.

Average Cover

Coverage is defined as the total number of plants observed at a given sample point. Each point on the graph represents averaging the plant coverage for all points on a given contour.

Overall, there is a general downward trend in total plant coverage moving from the high tide line to the low tide zone. Note the blue line and how it flattens out in the mid tide zone, and is higher than all other sites in the low tide zone. This is Hamm Creek, and I suspect this result is due to the portion of sampling that was done off channel in the marsh, where plants tended to fair better than along the river bank. This may also account for the variation seen. The general lack of coverage in the low tide zones may have important implications for restoration– if the sites are intended for salmon, perhaps more attention should be put on enabling plants to thrive in this zone, so refuge and food is available no matter what point in the tidal cycle salmon are there, especially when the location is not a shallow mud flat.

Another note about this data, is that it does not require the long and sometimes painful process of species identification, so it could be a fairly simple and more useful monitoring method, and could even enable citizen scientists to get more involved in the restoration process. This is because we are only measuring the “density” of plant coverage per sample location, which is independent of actual species. Additionally, I think it’s more meaningful in some ways than a few randomly placed transect or a couple quadrats, which is what currently constitutes sufficient monitoring.

Species Numbers Across Contours

Figure 18 shows the observed trends in total number of species across contours from high to low tide. There is an interesting convergence of the number of species in the low tide zone— very few species are present, and all contour levels approach between one and two species. This matches what is seen in the Coverage plot, and is visibly evident in the field— most sites have a strong demarcation line from a densely populated zone (in the middle-high tide ranges) and a sharp drop off from high coverage and number of species to very low abundance, volume (as assessed visually in the field), and coverage. South Park has the steepest decline in number of species, beginning right at the high tide line, whereas the other trends have a more gradual downward trend and the drop off does not begin until the mid-tidal zones— this is reflective of a more ideal restored state in a marsh habitat. However, it may be worth investigating whether more species, and what assemblage, might do well in the mid-lower tidal zones at all sites. Questions such as how the species and abundance may or may not influence use by and support juvenile salmon use potential should be considered.

Codiga Park 3D Visualization: Species grouping and representation of plants in different zones.

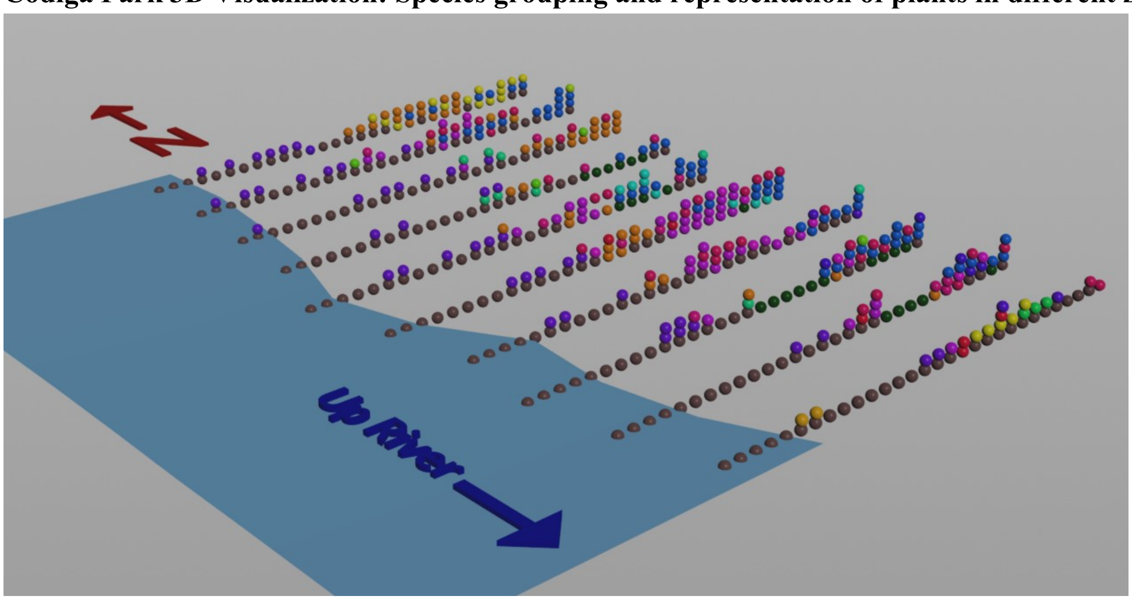


Figure 20: Codiga Park Point Intercept Plant Visualization, by Devon Penney

Discussion of species distributions and the low tide zone

This is a visual representation of the plant data as collected from Codiga Park, with each species represented as a different color. Each color is representative of a different species. The blue polygon represents the river, and this visualization illustrates a low tide condition, showing submergence of part of each 11.6 m transect. This visualization illustrate the method more precisely, and shows how individual species are distributed along transects or clumped together around the site, as well as what species are occurring in different tidal zones. For instance, the pink or fuchsia dots represents a species clustered in the mid tidal zone, with high coverage in this area, and presence at all layers. This is a species of intentionally-planted bulrush. In the low tide zone, there is very low coverage, and the growth is dominated by a single, short or low-growing species. Interestingly, this particularly low tide species, in purple, happens to be introduced, invasive species of water-starwort that shares the niche with two nearly identical-looking native species of Callitriche. I pose the question of whether or not an invasive species such as this should be removed in restoration monitoring-- it may be outcompeting other plants, but do the salmon care if it's native or not? Is it better to have no plants at all in the low tide zone, or to have decent coverage by a plant that's functionally beneficial for juvenile salmon?

6.3 Social Findings and Discussion

Overview:

Based on an exploratory and deductive thematic analysis of 16 intercept interviews and supporting social findings, I identified: the most common types of use within the study area, common themes and categories of human uses and perceptions of each site, factors influencing use or personal preferences, and the general knowledge and opinions people had about the restoration actions that took place. Through a secondary round of analysis, three common values emerged across the interviews.

6.3a. Categories of Use

There were many types of use by people, including aquatic wildlife viewing, relaxation, contemplation, and many forms of water-based recreation to name a few. These uses were either observed through participant observation, mentioned directly in the interviews, or learned about indirectly through elite interviews with key informants and casual conversations with people working in the study area. Use of the space varied across sites, and specific uses by site are discussed in site profile and/or summarized later in a Site Profile Table. I included use types that were mentioned or observed more than once in the analysis, to develop all-encompassing categories of use types. From there, I considered how these categories or forms of use compared to a typical park. Some uses were similar to what might be expected at a typical waterside park, and other uses seemed quite different. Later, I consider and discuss potential reasons for these differences, which may be influenced by specific (real or perceived) aesthetic and physical qualities of the sites. Overall, the use of these created green spaces was somewhat of a hybrid between what might be expected at a typical open space park and what might be more common within a more wooded or secluded natural area.

Categories	**Description and/or Examples**
1. Respite **	...from stressors and surroundings - Felt enclosed within a green space amid concrete/highly built surrounding environs; trees were primary influence - Watching river and boat activity; distraction. - Lunch break, quiet*
2. Relaxation	Sitting, reading, contemplation, passive enjoyment of nature/wildlife*; visual aesthetic is calming*
3. Ritual *	Morning snack with partner, stop by once a week or every day, coming for 30 years; go to with dog, or with a child for a specific purpose (e.g. child climbs rocks)
4. Recreation	Primarily water-based, though some beach and upland recreational use. E.g. fishing, kayak entry, active aquatic-oriented wildlife viewing*, dog wading/swimming, dog walking
5. Temporary encampments **	Tents at a few sites; other evidence of temporary living space including large piles of belongings and clothes; car-campers washing up in upland areas amidst trees. Changed over time in field
6. Alone time* and/or Privacy **	At most sites, most people were alone. Use by families or small groups was observed at some sites intended for use (parks e.g. Duwamish Waterway, Codiga). Privacy and quiet time were explicitly mentioned.

Figure 21: Table— Categories of human uses of restored shoreline sites

Figure 21 Key:

- **** two stars:** use type is **more likely to occur in these shoreline spaces** than a park
- *** one star**: use type is **slightly more prevalent here than in a park**
- **no star**: use type may be **equally or more common in a park** than it is in these spaces

Though the categories encompass all use types, some uses fall under more than one of the above categories. For instance, fishing for fun might fall under recreation, ritual, and relaxation. Coming down to the same spot on the water once a week to eat a donut and start the day could be considered a ritual, alone time, and a form of relaxation.

6.3b. Personal Preferences and Influences on Use

Below are the findings regarding preferences/influencing factors, the number of respondents that each one applied to, a note or brief reflection on each, and one or two supporting quotes. Often times, the response to a certain question illuminated additional insight about why people enjoyed spending time there and what influenced there decision to do so. These assumptions were used further in the analysis and discussion of site parameters and personal perceptions. The numbers are a combination of exact response out of a total of <u>16 interviewees</u>, and reasonable assumptions. Quotes reflect the true nature of the interview, but are not always exact.

<u>**Preferences and factors influencing use:**</u>

(A) **A natural looking or soft shoreline** N=12	**Reflection/Note:** …as compared to a bulkhead, pilings, or riprap. Some prefer this for the aesthetic; many prefer it for easier access. Direct access to water from the shore is critical for preferred uses at many sites, especially for fishermen, kayakers, and people with dogs to wade or run into the water.
	Quote(s): "…now, I come here with my dog. She loves the water. See [old dog teeters over to the water and flops down, panting]. She can't swim, but she just loves the water." "I've been taking him [child] here since he was little, it's like our local beach. You know it's small, but I can site [on the sand] by the water and he's just over there, he loves climbing on the rocks."
(B) **Built places to sit**	**Reflection/Note:** Many explicitly said they would not prefer benches, but liked when there were logs or other natural objects to sit on. Some brought their own chair. This spoke to the preference for a more natural feel. People seemed to like that there weren't any artifacts, or objects that were clearly built by humans.

N=4	**Quote(s):** "The logs to sit on feel like a tree cemetery... less like a bench and more of what the tree was when it was alive; it gives me a sense of peace." "No, I don't need to sit down. I usually don't stay for long, I drop by all the time on my way home, you know after work."
(C) **The surrounding views or aesthetic** N=16	**Reflection/Note:** Green: Every interviewee seemed to prefer a natural aesthetic, even if they knew that site had been created, versus a man-made look or feel. They appreciated the site b/c it's NOT a park. Many mentioned liking the feeling of enclosure by the surrounding trees. Blue: most everyone was drawn to the site in part to simply look at the water; they found it relaxing or soothing. At sites in the lower reaches, interest watching the shipping, small boat, and other human and non-human activity on the river.
	Quote(s): "People need places like this [beach]. Even though it's human-made, when I come here, it feels natural. You can hear the birds better, and feel the water." "The trees around the cove... they're like a hug." "There's just always something going on… these tugs and massive ships coming through, it's impressive. And then there's ospreys swooping down, seals- all the time! You wouldn't believe it."
(D) **Opportunities to view wildlife (birds, seals, fish, plants)** N=10	**Reflection/Note:** For many people, this was one of the primary factors influencing their enjoyment and choice to spend time there. They loved the opportunities for animal surprises!
	Quote(s): "One time I was fishing over there (points to rockbed in the river) and I threw a rock (makes gesture) and a sea lion came right over to it. It tried to scare the fish up! (Excitedly talks about the experience) I'm NOT talking about a seal, this was a sea LION." "… there are all kinds of birds. This is the best part of my day… some kind of raptor"
(E) **Condition of the vegetation** N=8	**Reflection/Note:** People tend to want to feel enclosed, but still have places to walk and some open space and trails in the upland. Respondents either felt very strongly about this, or did not seem to care-- typically when they were there for a recreational purpose.
	Quote(s): "This place is like a jungle! There are too many plants. There's nowhere to walk, especially at high tide."
(F) **Provides feeling of solitude** N=12	**Reflection/Note:** to "get away" or to feel peaceful or calm even if in a crowded area. Water may be a higher influencing factor here, as this conflicts slightly with answers to E- maybe some felt solitude regardless of amount and condition of the surrounding plants and/or did not make this connection
	Quote(s): "And I like the solitude… no one bothers me." "Hah, it's the only way I can get some peace and quiet"
(G) **Fishing –**	**Reflection/Note:** Some fishermen were inquisitive and friendly; many expressed curiosity about the vegetation surveys. One was formally interviewed. NWW and Codiga were the most

many/ not quantified *More people fishing were observed than interviewed	recreationally fished. Fishing for salmon from shore, the rock bed at NWW, and from within the river in waders for increases use level August through October.
	Quote(s): One fisherman waded into the water nearby while we were doing plant surveys. "This is so cool! It's good to know they're following up with all that restoration. Man, they just put so much work in." [He thought we worked for an agency].
(H) **Friends** **N=3**	**Reflection/Note:** *Mostly at Olympic Sculpture Park. Most people here were in pairs or small groups. Tourists and locals. All other sites: these are not particularly social spaces along the Duwamish; most people come down to the shorelines alone.
	NA

Figure 22: Table— Factors influencing human use

Further discussion of social findings:

Other key factors contributing to use included (1) a deep relation to the river, (2) proximity, (3) opportunity for surprise, and (4) appreciation for the specific site.

Most people expressed a deep and/or long term relationship with the river. "I used to come here to get a few roasters [chickens] back when it was a farm." Even a couple tourists expressed a long-standing connection to Elliot Bay, always returning to a particular waterfront spot. Some visitors lived or worked nearby, others said it was on a drive on the way home or that they came only on the weekend, or that it was the closest spot to fish. The nature of surprise on the river was interesting, as in, "You just never know what's going to come down the river. Sometimes I even see coal wash up… I collect it [laughs]". Many people reflected on this quality, and it may or may not have included the surprise aspect of seeing birds, fish, and other animals and interactions. Almost everyone interviewed conveyed a sense of appreciation for access to the space, despite having critiques about how it could be greatly improved. "Sometimes people have a small treasure in front of them, but they don't know it. You have to point it out, so they can notice it."

Additional insightful quotes and examples of coding:

Restoration concern: "Well, I grew up in a place that was wild. Not like this. But I really like it. … For years, no one cared if there was beach access. It's cool that the municipalities are doing what they're doing."

Access: "It's hard to find a place to enjoy the river. This is the only place I can go with access."

Maintenance: *"If you alienate humans, there's not going to be any interest [in stewardship]... people won't see the value. . . . It doesn't seem like the restoration folks have a plan." (Interviewee was referring to the fact that it wasn't inviting to people. There was not a lot of space to use, no bathrooms, lots of trash)*

Others; Management: "The fishermen, they come in and trample the place. It's a shame that there's not regular supervision. Fish and Game could check for licenses… it would help influence behavior, too."

Many of the people spending time at these shoreline sites seemed to know the particular spot well. Most seemed to only go to that location along the shoreline; some mentioned that sometimes they'd go to some other site. When asked how often they spent time at a site, some replied to the effect of "often or all the time", "all year long", "when it's nice out", or as a stop in transit from one place to another (e.g., in the morning, from work to home, on a lunch break). Some had deep local knowledge of the site, or spoke broadly about changes on the river in the recent past, which would often lead to a conversation about change in the area and region at a broader scale. For instance:

"You know… this guy sold off pieces of his farm, I think he hoped for this to be a place where people could enjoy the river. What he did was right. But, the way they constructed it-- what purpose does it serve?". "You know the Black River, there's a great riparian park, down by the Navy Area. There's a rookery - blue herons, with eagles eating the eggs! And lots of fish, too, and river otters... The Black is a tributary to here. It's just past the concrete recyclers. A lot of that STILL ends up in the river, you know. It's a complete mess, but it's starting to come back. Even the sewage treatment - the toxins, they just kill everything. But, this year, I actually heard frogs for the first time [at the Black River park]". I wondered if the slow movement of the river sparked the notion of change and time, and if the notion of the river as a connecting thread enabled different forms of reflection about connectedness in the region, and cascading impacts of changes at broad scales. Further, did the river provide a cognitive association with change, and did people think about the changes being made through restoration as static, or did they think of the sites as living, adaptive habitats?

Local community members, industrial workers, and business folks and others working nearby make use of these less-trodden, human-engineered natural spaces. For a brief time, they step out of the built grey landscape and into a built blue-green mini sanctuary. The sites are humble, yet impressive pockets of blue-green space connecting street ends to the river. Perhaps part of the allure and mystique is due to the stark contrast with the grey and highly developed surroundings. This idea of contrast, of "feeling like you're out in nature" yet knowing what's all around you came up frequently.

6.3c Values

In the analysis, I assessed commonalities between use-types across all sites and factors influencing use to identify the most prevalent values attached to or driving use of the space. The three most common values appearing across all sites were: first, solitude, or escape; second, direct water access, as opposed to a hardened shoreline, and third, routine or regularity with regard to amount and type of use. Values have been discussed throughout, and below is a summary of factors or examples supporting these values, or reasons for use that aligned with these values.

Value	**Supporting evidence**
Solitude	● Surrounded by plants—contributes to feeling of naturalness or "real" nature ● Un-park-like; not much infrastructure— contributes to feeling removed ● Uncrowded; not spaces for socialization, quiet ● Ample wildlife viewing in urban context, contributes to sense of peace ● Escape from daily stressors
Direct water access	● Blue-green space: water was a major source of appeal for most respondents, for both passive and active purposes ● Soft shorelines: contributed to an easier physical and improved mental connection with the river ○ Dogs, fishing, kayak entry, wading — would occur less if armored ○ Improved aesthetic, imagination, supports perception of spaces as a "local beach"
Routine	● Some people cited coming to the site on a regular basis: "best part of my day/week" ● Long-term connection, sense of place: many have known the river or have been visiting the site for many years ● Personal or family ritual: respondents mentioned regular visits "With my dog" or "With my kid" ● Morning donut/bagel/etc., and/or place to think before work

Figure 23: Table— Primary Values associated with shoreline uses and perceptions

Evidence shows that significant social value is coming out of the restoration actions occurring along the river. The spaces are not quite parks and not quite natural areas, and this seems to be important in their appeal. People using these spaces preferred the feeling of being removed from the built environment, or the way in which the aesthetic of the restored habitat at least allowed them to perceive or imagine such a feeling. The many once grey, now blue-green shoreline pockets contribute to an improved human connection to nature, well-being, and sense of place in the Lower Duwamish River.

6.4 Social-Ecological Synthesis

The study area as a whole constitutes a complex social-ecological system, and people using the space reflected on numerous factors driving changes along the river (e.g. Superfund status, lower snow pack, thoughts about fishery regulation and problems with or optimism about the cleanup effort). Here, I synthesized social findings with built and 'natural' aspects of each individual site. The below sections include: (1) a Social-ecological Site Profile Table, (2) three detailed individual site descriptions and reflections on their current condition from a social-ecological perspective, and (3) a map comparing use levels between people and salmon and discussion of the spaces from this perspective.

6.4a Social-Ecological Site Profiles

This Site Profiles table can be used directly or as an example for restoration practitioners aiming to integrate human use more intentionally into restoration site design. Additionally, an estimated comparison of use level by people and salmon is made, envisioning the plants as a connecting factor. These use levels are noted in the table as well as illustrated on a map below.

Social-Ecological Site Profiles Table

Character	**Olympic Sculpture**	**T108**	**South Park**	**Hamm Creek**	**NWW**	**Codiga**
Human use level	4 (highest)	1	1 (lowest)	2	3	3
Juvenile salmon use potential	3	2	1	3	3	2

Character	***Olympic***	***T108***	***South Park***	***Hamm Creek***	***NWW***	***Codiga***
Human use types/ primary activities observed	leisure, family, water/port views, tourist stop, surrounding trees, wildlife viewing, lunch break, beach exploration	lunch break, marine wildlife/bird viewing, views (water)(industry), privacy on beach side shoreward of LWD	temporary encampment, fishing	flat, wide beach, upland green space - sitting, seclusion, wildlife viewing, dog walking, multiple habitat views/aesthetics, fishing	fishing, ritual, direct water/rocks access, views, solitude, privacy - including people living in car/tent, lunch break, wildlife viewing	fishing, direct water access, dog, small boat launch, solitude, routine, views, wildlife viewing, contemplation, beach use, encampments
Restoration type and location	pocket beach off bay, adjacent to riprap and modified seawall	off-channel pocket - medium, and riverside shoreline	river-side shoreline	river-side shoreline/beach; marsh and side pocket, creek reconnected to spawning channel	off-channel pocket - large; wide opening	river-side shoreline/beach; side channel with narrow opening
Is the overall space and shoreline intended for human use? **How does design impact use?**	Yes - Public park. Two info signs, some upland trees, LWD placed for sitting. Adjacent paved trail.	No - shoreline private property signs. Yes at grass patch park (can't see water). Yes at street end bench/ broken concrete to tiny gravel patch on water, can view cove but not access	No - short fence along edge of sidewalk meeting upland plant area	No/Unclear - space for 4 cars; set back far from road; trail maintained through very dense veg to the water; signage about John Beale; not a park; no restroom	No -not visible or welcoming upland trail around back--dense trees, encampments; info sign obscured, not near water access path; bench on far side not visible; trail to water not marked, overgrown, eroding	Yes - parking lot, park, picnic table at the road. Walking trail leads to small beach, wade-in fishing, kayak/boat entry point, dogs go in water
Direct water access? **Available shoreline at high tide?**	Yes - soft shoreline made of gravel and cobble Yes, lots	Not intended- Street end bench with open views and crumbling riprap to tiny shoreline patch. Highly vegetated cove not easily accessible. Trespassing signs. Overgrown access path on north side of cove. NA	Yes - soft shoreline; but must step over fence. Not intended to be accessed – "Keep off for wildlife" signs. Flooded to upland veg at high tide.	Yes – soft flat beach, wide and spanning several hundred feet to the south. Sand/mud mix. No shoreline at high tide	Somewhat - Must use eroding unmarked trail to go down a steep bank riverside, or access from the small point/ of land—a muddy spit at the end of the trail. No	Yes - Nice inviting trail leads to beach, with easy water entry. Beach is very minimal at high tide. Mud/sand shore wraps around bend at lower tides.
Substrate/ground type in intertidal	open, gravel/rocks, LWD	highly mixed: large parallel logs with veg, highly vegetated cove and mud flat, small rocks and riprap to the south	narrow open mudflat, some tiny pebbles and sand	mud and sand on the river-facing shoreline, dense marsh veg on the creek-facing shoreline (south), muddier bank on the north creek side with root balls	very muddy, some remnant chunks of concrete	sand and trail in upland/high tide line, muddy, somewhat sloping bank

Secluded aesthetically?	somewhat - trees on north edge, shrubs on east edge	not at the street end; park is somewhat; people illicitly using beach space (secluded)	Yes - below street level under the bridge; a sidewalk runs parallel to the river, upland	Yes - very secluded, set back from road across a big field and tree line	Yes - short path leads to cove area - though partly visible from foot bridge, and very close to dead end road; tall tree and upland plant growth surrounding the habitat	Yes - long trail goes through tall and dense upland trees; can see some buildings across narrow river

Figure 24: Table— Social-Ecological Site Profile Summaries

6.4c Individual Site Profiles

<u>**Representative sites:**</u> **Hamm Creek, North Wind's Weir, and Codiga Park**

Hamm Creek, North Wind's, and Codiga represent structurally and functionally different habitat types designed and created specifically for salmon. These differences are described below. Additionally, the way in which these sites were used and the potential surrounding characteristics contributing to these uses are described. All sties experience semidiurnal tidal patterns; the maximum tidal difference can be up to 13 feet, resulting in a range of conditions for all human and non-human visitors. The selected sites represent the array of human uses and diverse surrounding conditions, as well as varying surrounding developments, communities, and type of access.

<u>**Hamm Creek**</u>
Restoration Summary: River mile 4.9; 1999 and 2003; 4.07 acres total: 2.98 ac. bank, 1.09 ac. marsh

Descriptive factors: bounded, hidden, not easily walkable, unexpected (as viewed from road), field with persistent invasive plants, dense trees upland, lush marsh, wide beach at low tide, higher than average bird activity.
Project Sponsor: King County/NRDA

Figure 25.1: Hamm Creek Study Site and Plant Survey Area in yellow.

Ecological Functions:

- *River bank, marsh, and creek habitat*
- *Medium-width opening to marsh*
- *Shaded, vegetated creek*
- *Spawning habitat*

Hamm Creek is situated just south of the South Park neighborhood, though a foot path or walking path does not connect them. It's set back from the road about 100 yards across a field of dead grass and flanked by the humming and imposing Seattle City Light power station. It's not easy to get to on foot and isn't the most inviting upon arrival. A foot and/or bike trail from South Park, and more extensively, a connected path running along the west side of the river from T105 to Cecil B. Moses could be a vast improvement to access at Hamm. The area is bounded by lots of different infrastructure, including a large boat building hanger to the north of the field. Yet, it's one of the most complex sites from a restoration perspective (USACE Monitoring 2005). Restoration included the creation of soft river bank habitat, with a medium opening to the marsh. The marsh connects to a day-lighted creek and salmon spawning channel.

Unlike some of the other sites, this one is unlikely to be stumbled upon or discovered on foot or by car. This site's location and situation— not visible, not marked, not in a typically "walked" area, largely explains the relatively low use. However, those who do visit and use the space attach a high value to it. Across the field from the road, the upland tree area feels natural, with a short, seemingly maintained foot trail leading to a secluded clearing within the trees where a couple plastic chairs stand waiting for visitors. The shoreline is not pristine, but it is an aesthetically pleasing place, especially in contrast to its surroundings. I suspect that contrast has a lot to do with the high value of this and other sites along the river. Those using the space spoke about the lush surroundings, open beach, and the feeling of seclusion as their primary motives for visiting.

There is a large amount of space to work with in the open field between the parking lot and upland riparian tree area. Planners considering restoring or converting the open field should consider what aspects of the space should remain as they are—open, currently used by dog walkers, and/or if ecological restoration might add additional value. Following an integrated approach and based on findings from this research, the site has high potential to be a natural-looking, mixed use area. This might include part preserve and part useable space, with a network of trails enabling viewing of preserve areas and a few information signs highlighting local species. How would a greening of the upland space influence use of the shoreline? While some ecologists and those responsible for mitigation might be hesitant to promote additional use, the field and beach area to the south of the channel mouth holds great potential for space that can be used and enjoyed by people without causing harm to the restored areas.

The Veteran's Conservation Corps is listed as the official "Stewardship Partner" and it's considered a legacy site where Vietnam veteran and local, John Beale, helped bring awareness to problems of pollution and degradation to a National level.

<u>North Wind's Weir</u>

Restoration Profile: River Mile 6.15 – 6.30; 2010; 2.88 acres total: 0.46 bank, 0.76 marsh, 1.66 mud flat
Descriptive Factors: fishing, ritual, direct water/rocks access, views, solitude, privacy - including people living in car/tent, lunch break, wildlife viewing

Ecological attributes:
- *Off-channel habitat*
- *High surface-area*
- *Very shallow/intermittently dry*

Figure 25.2: North Wind's Study Site and Plant Survey Area in yellow.

North Wind's Weir initially incorporated factors into the site design that were focused on social use, though these were solely focused on the upland area. This included an information sign with sponsor and partner logos, a dirt path along the perimeter (upland) that leads to a bench on the far north side. The bench, which was built and installed by a dedicated volunteer, overlooks the river, but the restoration/off channel area is not visible. Over time, as observed on site, the function of these designed attributes have changed due to a combination of the upland plant growth and physical constraints of the site (e.g. gravel lot and Pacific Shipping facility.). Now, the sign is not easily visible, and the upland plant growth is so tall and dense that the shoreline/restoration area is not visible from the path. Further, the path is densely vegetated and serves as a space for unsheltered community members, or people temporarily living in tents.

The road leading to North Wind's is a dead end, with some space for parking single file along the side. Trash piles up frequently in this area. On the south side of the road, there is a foot bridge that leads across the river to Cecil B. Moses, a restored site and public park. Additionally, the Green-Duwamish River Trail picks up on the south side of this road, running adjacent to a small office complex.

Interestingly, the only path that leads to the shoreline is obscured, unmarked, and not well maintained. On a late spring visit, thick bramble and rose vines had to be moved aside in order to reach the water along this path. The left side of the path drops off very steeply, with vegetation along the eroding bank along the river side. The path is less than 50 feet long, and leads to a small point of land, the size of which varies depending on the tide time. At high tide, it is just large enough for a few people to sit or stand on. At low tide, it is a muddy spit, and aquatic life is easily observable at the waterline. Some pieces of LWD have been placed here and in intervals around the cove. The shoreline and cove area isn't really intended for human use, nor is there much usable shoreline space regardless of the tide. This has to do with substrate type, as the mud flat area is incredibly mucky or difficult to walk in. The off-channel habitat (cove area) is inundated with water twice daily at high tide. However, the unique rock feature (labeled "Weir" in the image above) serves as a space for people to stand at mid to low tides. I observed people sitting, making phone calls, and fishing from this rock area.



Photos at NWW (left to right): People on the rock; Dan knew all of the lichen and moss growing on the installed logs; a five foot tall cairn.

<u>Codiga Park</u>

Restoration Summary: 2004 (inlet); 2009 (shoreline bank); 3.5 acres bank/1000 feet shoreline, 0.2 acres marsh, 0.5 acres mud flat. **Descriptive Factors:** Intentional park, though very minimal space at high tide. Long inviting path to river. Lots of water-based recreation: kayak put it; fishing. Many people sleeping/sitting in cars in lot.

Ecological Functions:

- Highly dense veg upland
- Long, gently sloped river bank
- Narrow opening to long and regularly dry side channel – note, inaccessible by people

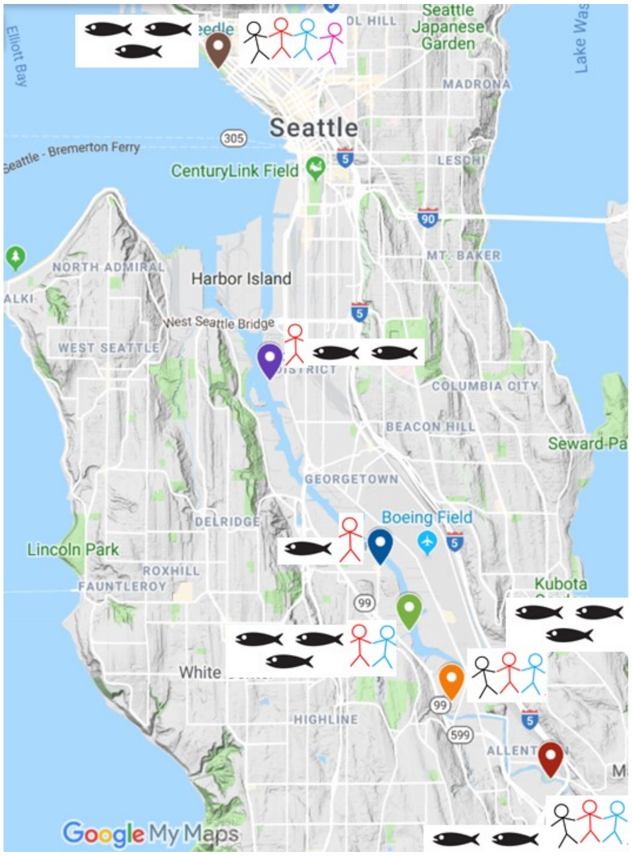
Figure 25.3: Codiga Park Study Site and Plant Survey Area in yellow.

Codiga is a designated park, unlike the other sites, and is flanked by highways and right off a trucking route. Many people drive down the hill to park and stay in their cars, not even going out to the water. For other visitors, it functions in a similar way to other sites, but with easier and more obvious access, resulting in higher use. However, there is still very little space for people to use at mid and higher tides, which was noted as problematic. The upland is really dense and the off-channel creek is not easily reached. The bank is steep and muddy to the north, and slightly more sandy and usable to the south.

<u>Interview quotes reflecting some perceptions of Codiga and work done:</u>

“You know… this guy sold off pieces of his farm, I think he hoped for this to be a place where people could enjoy the river. What he did was right. But, the way they constructed it-- what purpose does it serve? It’s not accessible. [points to the trees]. You can’t even go in there! Supposedly there’s a long creek now, for the salmon. I think it’s dry most of the time! And you can’t get down there; most people don’t even know it’s there. And here, [points to river] there’s barely any water in the river at low tide.”

6.4d Use by people and salmon



The Duwamish River shoreline sites typify social-ecological systems, and much variation exists between different sites within the study area.

Figure 26: Site use levels by people and salmon, by CJC.

This map shows approximate or representative levels of use and utility at each site by people and salmon. One (1) is very low; four (4) is very high. Potential or estimated use levels by salmon was determined through a review of various studies (Cordell et al. 2011; Dethier et al. 2016, Toft et al. 2016) and my own observations about the vegetation and current condition of the sites as they might influence access and use by juvenile salmon. As mentioned previously, a wider opening to off-channel habitat may improve access by juvenile salmon. So, looking back to the three representative site profiles, North Wind's would be most accessible, followed by Hamm, followed by the long narrow inlet at Codiga (2004 construction) being least accessible as it has a very narrow opening from/to the river.

Human use level is assigned based on my own observations at the sites, with nearly 30 or more site visits in total. Amount of use, and the typical number of people observed on any given visit, was lowest at T108 and South Park, slightly higher at Hamm, which is perhaps the most underutilized site from a social perspective, and more prevalent at NWW and Codiga. Awareness or visibility of the latter two sites is likely contributing to their relatively higher use levels. As expected, use level and frequency at the Olympic Sculpture Park on Elliot Bay was much higher than other sites, often with 50 or more people observed on site on the weekend. However, people used this space in a very different manner, often just passing through, or spending roughly 5-10 minutes of time there as opposed to 30 minutes – two hours at other sites. It was more of a tourist stop for many, though a few people using the Sculpture Park spent up to an hour there and spoke of a connection to this site as well, despite it being heavily trafficked and a much more social spot. The pocket beach at Olympic Sculpture Park is near the Seattle Seawall Project, which has been modified to accommodate the same juvenile salmon that have made it out of the Duwamish River. There could be an opportunity to highlight this connection to the Duwamish River for the public through this highly visible project and high-trafficked area.

It is worth considering that people and juvenile salmon tend to seek similar conditions. First, they seek the right amount of vegetation – not too dense or too sparse. Second, they seek escape from everyday stressors, such as thesis writing, or predators. And third, they seek water– water rejuvenates the body and mind (Nichols 2014). Though this perspective is somewhat imaginative, figuratively placing people and salmon in the same realm might enable planners and the community to better conceptualize these and similar restoration spaces as places that can be shared by both. That is, the small blue-green pockets created along urban shorelines can be spaces for people and salmon.

Restoration "for salmon" implies that planners are taking a biocentric, rather than eco- or anthropocentric value orientation (Hertog and Turnhaut 2018). Though these shorelines are specifically designed for salmon, they are highly utilized by people, in a variety of ways. While these uses vary across sites, they have similar influences, such as the surrounding conditions and aesthetic quality of the plants, and are perceived as unique and valuable places that contribute to improved well-being. The spatial and functional boundaries of sites also influence access, which reflects the SES perspective. The Duwamish River basin is geographically isolated on the east and west, by both highways and hills. This isolation has consequences for some marginalized communities in the area who may face social barriers to resources, and often do not own cars. Considering how both people and salmon, and perhaps other plants and animals could benefit from future restoration sites, and integrating this approach to planning could enable improved access and connection, and the subsequent long term community investment in urban restoration.

7 Recommendations and Conclusion

“The Duwamish is still so wild, and that’s kind of what I love about it.”

– S. Kavage, artist and urban planner

“In restoration, nature is co-created.” (Garvey 2016)

Most of the once wild, lush, marshy green spaces in the Lower Duwamish River were erased over half a century ago, in the name of Western control and progress (Klingle 2005). Today, green spaces have begun to be put back in place, co-created by humans and nature, intervening and intermingling with new, novel habitats. The sites were not built to provide justice to nature or people, but largely due to policy mandates and to support the tribal, commercial, and recreational salmon fisheries (State of Our Watershed 2012). However, these newly created green spaces, or restored shoreline habitats, have become wild in a different way. They stand in stark contrast to their industrial, grey, impervious surroundings. Salmon may notice them, so to speak, on their migrations through the estuary. Juvenile Chinook swim into the muddy banks and eat atypical prey items (Simenstad and Cordell 2000), while invasive Canada geese take advantage of the planted native sedges nearby. In the fall, a Muckleshoot fishermen sets a net to catch returning salmon as they attempt to make their way up river to spawn.

Though incalculable amounts of time, effort, and money have been put into restoring shoreline habitat to remove toxins and support juvenile salmon, progress is slow and the amount of benefit to the salmon and to the ecosystem as a whole is difficult to quantify (Simenstad et al. 2005; David et al. 2016). However, though social benefits are arguably more visible, not much attention is focused on assessing this metric of success. Despite certain site constraints and less than ideal access and accommodations for people, the novel habitats that have been put in place for salmon have slowly become both sacred and every day spaces for local community members, as well as those making a living in varying ways along the river. The many restored blue-green spaces along the Lower Duwamish River have become uniquely a part of people’s sense of place in an otherwise grey environment.

These habitats are almost definitely outside the Historic Range of Variability (Garvey 2016), and may not be self-renewing or sustainable without additional human intervention on a long time scale. This is in part due to where they're situated, on a tidally influence and thus sea-level-rise prone estuary, where adjacent vegetated upland areas are relatively low-lying and narrow. As sea level rises, not only will communities be at risk of floods, but the multi-million dollar habitat projects that were made for juvenile salmon may be at risk of degradation, as the intertidal zone migrates closer to the concrete. This is the case within many urban ecological sites, yet restoring to historic conditions are still held as the golden standard by many within the field of restoration ecology.

On plant surveys and monitoring:

Effectively monitoring and studying plants can be an incredibly time-consuming and often tedious process. From our experiences in the field and the many long hours assessing samples and attempting to identify species, the time spent amongst the plants is often gifted back. Despite being situated as a speck of green in the greater surrounding grey landscape, there's a feeling of naturalness, of being in nature, even if this particular slice of nature was originally built by people. The plants are still plants, the mud is still mud, and the insects and fish making use of them likely don't know or care how the plant assemblages got there, or whether or not they're considered invasive, for that matter. Plants sometimes provide unexpected wisdom.

On the practice of restoration in the Lower Duwamish River

If there's one aspect of Leopold's conservation ethic that might have trouble holding up in the urbanized areas of today's world, it's the focus on "self-renewing ecosystems" as prerequisites for reversing the land sickness (Leopold 1949, p. 272). As habitats are erased and ecosystems continually degraded, people attempt to bring back what was lost -- thus the ever-growing practice of ecological restoration, in its various forms and contexts. But in human-dominated, heavily developed, and polluted landscapes such as the Lower Duwamish River and elsewhere, restoration practitioners and scientists need to increasingly set a different standard, and to accept reliance on ongoing human support and intervention to reverse our damages. Human support stems from connection to the space and belief that restoration efforts are a worthwhile investment (Simenstad et al. 2005). Rapidly shifting climate patterns are another challenge to continued ecological restoration, as changes in temperatures and plant assemblages alters the distributions of species (Wilkening et al. 2015).

To this end, hybrid or novel ecosystems or novel habitats existing outside the historical range of variability may be better targets than a self-renewing ecosystem, or “fabled baseline” (Garvey 2016). In the Duwamish, all restored shorelines can be considered novel or hybridized. Some introduced species may be outcompeting natives, but this may not necessarily be a bad thing. More work should be done to assess this, and to better understand the role of prevalent introduced species in the intertidal, their influence on community plant composition, and subsequent impact on juvenile salmon. That is, do certain introduced species, such as *Callitriche* or other primarily low-tide aquatic plants provide benefits to juvenile salmon? It may be difficult to quantify the numerous urban influences on the ecology of sites, but developing a better understanding of how these spaces are changing over time is a good first step. In practice, this means conducting more thorough and frequent surveys of intertidal vegetation, and perhaps enlisting community scientists to aid in this process.

Aldo Leopold claimed over 60 years ago that "artificialized management [of trout] has in effect bought fishing at the expense of another and perhaps higher recreation; it has paid dividends to one citizen out of capital stock belonging to all" (Leopold 1949, p. 285). This analysis is relevant to hatchery management and restoration “for salmon” in the Green-Duwamish River today. “Traditional restoration ecology was driven by “specific historically based goals” (Higgs et al. 2014). However, a newer approach to restoration uses historical knowledge as a guide, as has been the case in the LDR replanting strategies. It also “accepts multiple potential trajectories for ecosystems” (Higgs et al. 2014), which is a crucial philosophy to employ when factors influencing restoration outcomes in an urban environment are hard to predict. And finally, it “embraces pragmatic goals for human well-being” such as those discussed in the Environmental Health Disparity Index (DOH n.d.). Restoration in the LDR should seek to further emulate this newer approach, including being open to potential trajectories that include the acceptance of some introduced species that fill important niches. Further, restoration planners should recognize the enormous social value that sites are bringing to people, and seek to improve existing sites and incorporate local preferences into new site designs. By integrating human well-being benefits into restoration goals, the ongoing community support needed to keep restoration efforts afloat will have a better chance continuing and growing in the future.

When habitat restoration is proposed, several decisions should be made before action is taken. A study on common beliefs and values of restoration practitioners found that the main dilemmas in restoration revolve around the why, what, and how (Hertog and Turnhaut 2018). That is, *why* to restore, *what* to restore to, and *how* to restore. In the Lower Duwamish River, most restoration implementation, or more appropriately, the creation of shoreline habitat where parking lots and old buildings once stood, has been driven by CERCLA and the ESA, though tribes and grass roots organizations have played a vital part in the stewardship of these hybrid or novel habitats.

Based on the results of this social-ecological research, it is evident that more attention should be placed on all three aspects (why, what, and how), but primarily on the 'why'. It is clear that people, often those who are already facing environmental injustices, are benefiting from and value spending time in these created blue-green spaces. Yet, though the sites are being used by people, they are not realizing their full potential, from both an ecological and social perspective. From an environmental justice perspective, one goal of shoreline restoration in the Lower Duwamish and other urban areas should be expanded to incorporate intentional human use.

Minor changes could be made to existing shoreline sites to improve their use by people and perhaps enhance their ecological function over the long term. Some of these might include simple and fun educational signs in a visible location outside of the space, and accessible naturalist information about the site and the restoration efforts. Almost everyone interviewed along the river was incredibly interested in learning more about "how the river was doing" and what was going on with restoration and why.

Overall reflections and ideas for improvement:

1. Add an art element: there was a suggestion for the city to hire an artist in residence to work along the river.

2. There is not a lot of space to walk or sit at mid to higher tides. They could cut some upland trees to make more room for people—not too many, just enough— particularly those in the middle or back of the upland zone.

3. Provide more opportunities for school and community groups to learn about and visit restoration sites (those that are not parks). Improve opportunities for people to learn about ongoing projects, help with clean up, become stewards, increase connection to place and build community.

4. Boeing, the City of Seattle, and King County could allocate funds for access improvements and/or research into human well-being as part of their mitigation mandates.

Many conversations and interviews elicited the idea of potentiality. When riverfront land becomes available, people think about all the potential it has to be something valuable— whatever "valuable" may mean from their perspective. Perhaps there is a sense of idealism, an imaginary version of what land on the river in a particular stretch has to offer the community, and the potential for a return to "nature" - as reflected by the quote "why didn't they let [nature] do its thing?" regarding the modification of one more southerly site.

Though sites are ecologically novel at their creation, they have become hybridized forms of what was engineered by humans and what nature has done since their inception or development. In highly developed, concrete-covered areas, a full return to natural processes is likely not possible or feasible. However, some degree of "letting things be" (Matthews 2004) after sites have been in place for a while might be beneficial. While it is well-accepted that landscapes or ecosystems are anything but static, it can be difficult to allow or enable natural processes to occur in areas that are highly developed or that society permanently occupies. However, some acceptance of a novel or hybrid ecosystem that supports social benefits could increase the overall potentiality of relatively small urban restoration projects.

There is much to gain in the field of social ecology and environmental ethics by choosing to do nature-based research in urban and other human-dominated areas. From a feminist-science perspective, this choice is a political one, one that reflects that at least the majority of ecologists publishing studies value nature that's "out there"- protected from human "destruction", more than the nature that's right in front of us, hiding in plain sight. Despite a growing interest in and practice of ecological restoration, the connection and direct well-being benefits are not well studied or understood. Feminist science pushes for questions to be asked and research to be done in ways that do no advance harmful policies and institutional structures (CLEAR n.d.). What are some restoration management and policy options that could be considered to move society in this direction? When planning landscape and local-scale restoration projects:

1. Apply a decision-tree or procedural model to determine predicted positive and negative outcomes of incorporating human use into restored urban shorelines versus maintaining the status quo.
2. Modify existing and design future restoration sites to include intentional human use. Inform the design by these interview findings and ongoing community engagement, using methods outlined and described in this work, along with organized community meetings.
3. Examine potential changes to the Shoreline Master Plan 'environment' designations, under planning phase three. Could a specific "Social-Ecological" designation encourage more shoreline use to intentionally integrate human use, where appropriate, into natural and restored spaces?

Given what we know of the Lower Duwamish River I argue that current and future restored urban shoreline sites should be intentionally designed for use by people, and that this principle can be applied to other similar geographies and urban-natural spaces valued by humans. Practitioners should set the restoration goal of a novel-ecosystems versus some "fabled baseline" (Garvey 2016) that we can't achieve and wouldn't know it if we did due to lack meaningful monitoring. Lastly, if "restoring estuaries are a social, economic, and cultural investment" (Simenstad et al. 2005), then we should aspire to place more value on human use of coveted space, through our policies and actions, not just our narratives. Conservationists and restoration practitioners should shift the focus and attention from the wild and scenic nature to the nature that's in our urban "backyards" and shared spaces, in order to move toward a justice-oriented approach to restoration (Marris 2013; Garvey 2016). This includes placing equal or higher value on nature in urban areas as we do on the removed or far-off wilderness or other areas traditionally thought of as natural. One way to do this is through regular and creative engagement with the public, or through more careful and context specific restoration design, including incorporating intentional space for human use.

I recognize the people of the Duwamish Tribe, past, present, and future, and am grateful to work on the river named for them in the city named for their chief, Si'ahl.

Photos from explorations along the Lower Duwamish River, by CJC.

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Appendix

Interview Guide
By Cori Currier - 2018
Intercept Interviews on Restored Urban Shorelines

1. When would you say you typically spend time here, and about how often?
    a. Does this vary seasonally?
    b. Do you usually come at a particular time of day?
        i. If so is there anything that you like about being here at this time?

2. How long does it take you to get here (from work or home)? How do you usually get here?
3. Do you consider yourself to be a local resident?
a. How long have you lived in the area?
b. How long have you been coming to this spot?
4. Can you tell me a bit about a typical visit?
Prompt: What kinds of things do you...do/see/feel..?
5. What do you like most about spending time here?
6. What have you been surprised by, either over time or during a particular visit?
7. Does visiting or spending time here have a special significance to you or to your life, and if so, can you describe that?
8. Has your experience and perception of the park changed over time, if so, in what ways?
9. Are you familiar with any restoration work that has happened here?
a. How did these changes/ the restoration work impact how you felt about this site in the long term?
10. Did you spend time here before it was restored/converted to a more natural shoreline?
a. If not, what factors/things would you say lead you to begin spending time here?
11. Do you typically go to any other places or businesses nearby or on your way to or from this spot?
How often?
12. What aspects would you say are important in your decision to come here? (use and access)
a. A natural looking shoreline and/or direct access to water from the shore, that is, as opposed to a bulkhead or riprap shoreline
b. Built Place(s) to sit/benches
c. The surrounding view
d. Opportunities to view wildlife
e. Condition of the vegetation
f. Provides feeling of solitude
g. Fishing
h. Friends
Other:
13. When interviewing people fishing: If you were not able to fish here, would you fish elsewhere during this time (time and day of the week)?
a. If yes, what additional costs would you incur in doing so? At what point might you consider these to be prohibitive?
14. What other factors influence your decision to come to [name of site] as opposed to going elsewhere? If x conditions were different, would you consider going to another site? Are there other restored sites that you visit and what do you think of them?

15. What would you change about the access to or at this site given the opportunity?

16. In your opinion, what are some positive and negative impacts of improving the environmental [ecological] conditions of the site, with regard to your personal experience here?