Maximizing ecological and social benefits of habitat restoration in the Lower Duwamish River:

A spatial framework for site selection

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Abstract

Maximizing ecological and social benefits of habitat restoration in the Lower Duwamish River:
A spatial framework for site selection

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The Lower Duwamish River (LDR) estuary is an 11-mile stretch of river that contains the core of industrial activity in the Seattle area. As the city's only river, the LDR also provides important habitat for many of the region's valued fish and wildlife species. However, its long history of urban development and industrial activity has polluted and degraded the river, and significant habitat restoration is now required under federal and state law. Given the highly developed urban industrial setting of the LDR, habitat restoration projects tend to be opportunistic and small, with limited ecological value. At the same time, the LDR is home to several underserved urban neighborhoods, and restoration projects have the potential to bring significant social value to these communities. Maximizing this potential value together with ecological value requires a more strategic approach to restoration. Through a review of local and regional planning documents, I developed a list of community-defined characteristics that contribute to a restoration project's potential ecological and social value in the LDR. I then used these characteristics to explore the spatial distribution of potential restoration value in the river, creating a series of heat maps of potential value for each characteristic, and for overall potential ecological and social value. I developed six ecological metrics and eight social metrics, which I calculated for 511 waterfront parcels in the LDR. Results show more variability with positive skewness in the ecological index, and a more normal distribution with higher average values in the social index. Spatial analysis revealed higher ecological value in the northern, industrial section of the LDR, with particular dependence on the existing habitat network. Social value was higher in the southern section and as the river passes through residential neighborhoods. These results can inform site selection for future restoration projects in the LDR. Methodologies and results for individual metrics can be used to address project-specific objectives, while use of the complete collection can inform those restoration projects that seek to maximize overall ecological and social benefits in the LDR.

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Finally, I must thank my parents, Chris and Cindy, who have always taught me to ask questions and challenge myself, and who assure me I can accomplish anything and everything; and my partner, Trevor, for loving and supporting me even when I can’t.

Table of contents

List of figures

List of tables

Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
DCLG	Department for Communities and Local Government
DRCC	Duwamish River Cleanup Coalition
dSAY	Discounted Service Acre-Year
GIS	Geographic Information System
GMA	Washington State Growth Management Act
HEA	Habitat Equivalency Analysis
HFA	Habitat Focus Area
KCGIS	King County Geospatial Information System data portal
LDR	Lower Duwamish River
LDW	Lower Duwamish Waterway
MCDA	Multi-criteria decision analysis
MIC	Manufacturing and Industrial Center
NOAA	National Oceanic and Atmospheric Administration
NRDA	National Resource Damage Assessment
OHW	Ordinary High Water
OHWM	Ordinary High Water Mark

PRP	Potentially Responsible Party
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
RCW	Revised Code of Washington
RM	Duwamish River Mile
SDOT	Seattle Department of Transportation
SER	Society for Ecological Restoration
SMA	Washington State Shoreline Management Act
SMP	Shoreline Master Program
SSD	Shoreline Substantial Development
WAC	Washington Administrative Code
WAGDA	Washington State Geospatial Data Archive
WDFW	Washington State Department of Fish and Wildlife
WRIA	Watershed Resource Inventory Area
WSDOT	Washington State Department of Transportation

1 Introduction

The Lower Duwamish River estuary is an 11-mile stretch of river that contains the core of industrial activity in the Seattle area. As the city's only river, it is also important habitat for many of the region's valued fish species, as well as home to active First Nation tribal fisheries. Industrial activities wishing to develop and build within the waterway are required by state and local regulations to offset impacts to these natural and cultural resources through nearshore habitat restoration. Due to the designation in 2001 of a five-mile stretch of the river as a Superfund site, significant additional restoration is required of certain parties by federal mandate under the Natural Resource Damage Assessment (NRDA) and Restoration Program. As a result, the Duwamish River estuary now has the largest concentration of estuarine restoration sites in the Pacific Northwest.[1]

As an active urban industrial center, the waterway is almost entirely developed, and land values are high. Habitat restoration occurring within the waterway must therefore be opportunistic, and projects tend to be small. Given the context of urban development and industrial activity, the ecological value of these projects can be limited.[2]

However, for the same reason these projects may reap few ecological rewards, they have the potential to garner significant social value. Their location in an urban setting inherently means they are located closer to a large number of people. This on its own may bring value above that of similar, more ecologically valuable projects located farther up in the watershed. Furthermore, in an urban environment, "nature" is arguably a social construct, defined by the

[1] Simenstad et al., "Challenges of habitat restoration in a heavily urbanized estuary: Evaluating the investment," 2004.
[2] *Ibid*.

interaction between people and their environment.[3] Thus, when we consider social benefits, the value of a restoration project is enhanced by its proximity to and relationship with the communities around it. In the case of the Lower Duwamish River, which runs adjacent to two of the most underserved residential communities in Seattle, the opportunity for such value is perhaps higher than anywhere else in the region.

Maximizing this social value together with ecological value requires a more strategic approach to restoration.[4] Various federal, state, and local management and planning authorities, such as the Duwamish-Green Watershed Resource Inventory Area and the City of Seattle's Department of Planning and Development, have developed specific priorities and hierarchies used to accomplish ecological restoration goals in the Duwamish River estuary and greater Puget Sound region. For example, federal authorities managing restoration under the NRDA process assign the greatest value to projects within the five-mile stretch of the river designated as a Superfund site, and lower value to projects within Elliott Bay, located immediately downstream of the river mouth.[5] At the same time, traditional planning efforts at the regional and neighborhood levels have been underway for decades. With community input, these efforts have identified priorities and strategies for bringing social and environmental amenities to the Duwamish River Valley. For example, the Duwamish River Cleanup Coalition completed a formal visioning process with these communities in 2009, generating a detailed set of maps that express the Valley's identity and goals for the future.[6]

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[3] Bird, "The Social Construction of Nature: Theoretical Approaches to the History of Environmental Problems," 1987.

[4] Buckley and Haddad, "Socially Strategic Ecological Restoration," 2006.

[5] National Oceanic and Atmospheric Administration (NOAA), "Final Lower Duwamish River NRDA Restoration Plan and Programmatic Environmental Impact Statement (EIS)," 2013, 4.

[6] Duwamish River Cleanup Coalition (DRCC), "Duwamish Valley Vision Map & Report," 2009.

This thesis work attempts to resolve the diverse goals defined by these various planning efforts in order to inform decision-makers *where* in the Lower Duwamish River to restore habitat for maximum ecological and social value. Through a review of local and regional planning documents supported by academic literature, I developed a list of characteristics that contribute to a restoration project's potential ecological and social value. I then used these characteristics to explore the spatial distribution of potential restoration value in the river. Using the spatially-explicit characteristics from the list, together with geospatial information about the study area, I created a series of heat maps of potential value for each characteristic, and for overall potential ecological and social value for restoration in the Lower Duwamish River.

Figure 1-1: Map of the Lower Duwamish River, showing location relative to the cities of Seattle and Tukwila.

In emphasizing the spatial distribution of potential ecological and social value throughout the entire Lower Duwamish River, this research departs from several other prioritization efforts that are driven by financial feasibility and the realities of land ownership. For small, one-off restoration projects undertaken by private parties or community organizations, money and opportunity must be the primary drivers. However, for larger institutions that own land throughout the Duwamish, such as the four primary parties responsible for restoration under NRDA,[7] selecting a site that will yield maximum value can be the hardest and most difficult step in the restoration planning process. The maps and information generated by this thesis work are intended to serve as decision-support tools for these larger institutions as they plan for future restoration projects. As with any such tool, they should be used in concert with local, project-specific information, and should be updated with the most current data available. Used in this way, they are intended to be an important component of a flexible decision-making framework operating in a dynamically changing environment.

[7] Port of Seattle, City of Seattle, King County, and the Boeing Company.

2 Background and problem definition

2.1 Defining habitat restoration

Habitat degradation is the hallmark of human development. Ever since the first European settlement in Puget Sound in the 1800s, humans have been engineering their environment to suit the needs of modern civilization. In doing so, we have fundamentally altered natural ecosystem processes. The practice of habitat restoration aims to restore these processes and, in so doing, create high quality habitat for fish and wildlife. Early definitions of restoration describe it as a "means to return an ecosystem to its original condition."[8] The Society for Ecological Restoration defines ecological restoration more broadly as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed."[9] Miller and Hobbs expand on this definition to more explicitly acknowledge restoration objectives: "The process of habitat restoration can be viewed as an attempt to move a given area from a degraded state of relatively low habitat quality toward a target of improved condition."[10] This definition permits those performing restoration to define a wide range of objectives, or targets, such as restoring specific levels of diversity or productivity; restoring a habitat to be suitable for one or more target species; restoring desired aesthetic qualities or recreational opportunities of an environment; or restoring a historic ecosystem.[11] It is therefore the most appropriate definition to use in the context of habitat restoration in the Lower Duwamish River (LDR). Alone among the other definitions, it acknowledges that restoration is defined by the values of those performing the restoration, and can achieve objectives beyond purely ecological ones. Furthermore, due to the

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[8] National Research Council, "Restoration of Aquatic Ecosystems," 1992.
[9] Society for Ecological Restoration, "The SER Primer on Ecological Restoration," 2002.
[10] Miller and Hobbs, "Conservation Where People Live and Work," 2002.
[11] Davis and Slobodkin, "The Science and Values of Restoration Ecology," 2004.

highly developed and degraded nature of the LDR, restoration back to an original state at any scale is not feasible. Therefore, “habitat restoration,” or simply “restoration,” as it is used in this document, refers to any activity that rehabilitates, enhances, or recovers “ecosystem processes, structures, or functions on a site through the use of management measures.”[12] Management measures, or restoration activities, may fall anywhere on the spectrum from minimal planting of riparian vegetation to full stressor removal and restoration of ecosystem processes. This definition is also independent of the purpose of activity; no distinction is made between restoration projects that directly offset habitat loss (sometimes called mitigation projects) and those performed for other reasons.

2.2 Habitat restoration in an urban estuary

2.2.1 Constraints

Due to the constraints of an urban environment, habitat restoration in an urban estuary such as the Duwamish involves unique challenges, risks, and uncertainties. Ecosystem structure and function, and the underlying processes that support them, are often completely altered and degraded due to prolonged and extensive urban development and contamination. Land values are high and space is limited, and habitat is unlikely to be zoned as a preferred use in urban areas where industrial, commercial, or residential shoreline property is in demand. As a result, restoration sites tend to be small and fragmented. Without the support of surrounding intact ecosystem processes, the ecological success of such sites is questionable.[13] In addition, because of competition for land, long-term protection for restoration sites can prove difficult to acquire, further compromising ecological value. Therefore, despite increasing restoration efforts over the

[12] Cereghino et al., “Strategies for Nearshore Protection and Restoration in Puget Sound,” 2012.
[13] Simenstad et al., “Challenges,” 2004.

last decade, the recovery of estuarine ecosystem processes and functions in urban or industrial settings remains uncertain, calling into question whether restoration in such settings is ecologically or financially sustainable over the long-term. In many cases, rehabilitation or enhancement of ecosystem function or structure must substitute for full restoration of ecosystem processes.[14] As they result in ecosystems that are still somewhat impaired, such projects will always require active monitoring and management. In such cases, community support of the project can mean the difference between failure and long-term ecological success.

2.2.2 Opportunity: Social dimensions of urban habitat restoration

Fortunately, "ecologists are beginning to recognize the key role that social values plan in determining the outcomes of restoration."[15] Local support for restoration can facilitate project implementation, resulting in larger, more ambitious projects with more access to funding and human capital.[16] Following construction, community support can ensure long-term protection, preventing redevelopment of the site as something other than habitat. Involved communities can also perform the long-term maintenance and monitoring tasks necessary for long-term ecological success. The importance of public acceptance increases with the intensity of human settlement in the surrounding landscape.[17] In urban landscapes dominated by human activity, local support for restoration can translate into "social buffers," which can greatly enhance habitat quality and increase effective habitat area.[18] For example, a community that understands and supports the objectives of a restoration project may be more willing to alter its behavior to help reduce detrimental edge effects that often result from human activities.

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[14] *Ibid.*
[15] Davis and Slobodkin, "Science and Values," 2004.
[16] Dyson et al., "Planning and Management Guidelines for Coastalscape Revitalization: Case Studies from the Salish Sea Region," 2013.
[17] Miller and Hobbs, "Habitat Restoration – Do We Know What We're Doing?," 2007.
[18] Van Driesche and Van Driesche, *Nature Out of Place,* 2002.

A sense of community ownership will increase the amount and frequency of visits to the site by local residents. This increased interaction also maximizes the social value of the site; indeed, community involvement and support can completely redefine urban restoration, valuing it more for its passive recreational or aesthetic uses than for the less-tangible concept of ecosystem function.[19] Habitat restoration can have a substantial impact on the quality of life in urban settings, with benefits to physical and mental well-being, social cohesion, education, and culture. Restoring habitat can put people in closer contact with nature, which is particularly relevant in urban environments where green space may be wanting, and where people need respite from the stresses and strains of city living.[20] Many restoration schemes at public parks have resulted in increased and more prolonged park usage, which results in more active, healthier communities. Well-designed restoration sites can provide free, accessible, and safe recreation opportunities for children and adults, as well as opportunities for education. Sites can serve as gathering spaces, playing a vital role in the community by encouraging social interaction and bonding.[21] Habitat can also enhance the aesthetics of a neighborhood, fostering a sense of place and community pride. Research shows post-restoration improvements in social behavior such as reduced graffiti and littering.[22] Natural landscapes have long provided inspiration for art, music, folklore, and architecture, and are historically a part of human culture and spirituality. As a result of the large number of people in proximity, in an urban environment even small improvements to habitat can achieve these social benefits.[23] In other words, the social value of habitat restoration is maximized in an urban setting.

[19] Simenstad et al., "Challenges," 2004.
[20] European Centre for River Restoration, "Social Benefits of River Restoration," 2013.
[21] *Ibid.*
[22] *Ibid.*
[23] Findlay and Taylor, "Why Rehabilitate Urban River Systems?," 2006.

2.3 Habitat restoration in the Lower Duwamish River

2.3.1 Historic degradation

The Lower Duwamish River is the lowermost extent of the Green/Duwamish River system, a 93-mile system that originates in the Cascade Mountains and flows generally west and northwest toward the City of Seattle.[24] Tidal influence is observed upstream approximately eleven miles to the point of confluence with the Black River in the City of Tukwila. This stretch of the river is a brackish estuarine environment referred to as the Duwamish estuary.[25] The last 4.6 miles of the estuary are located in the City of Seattle.

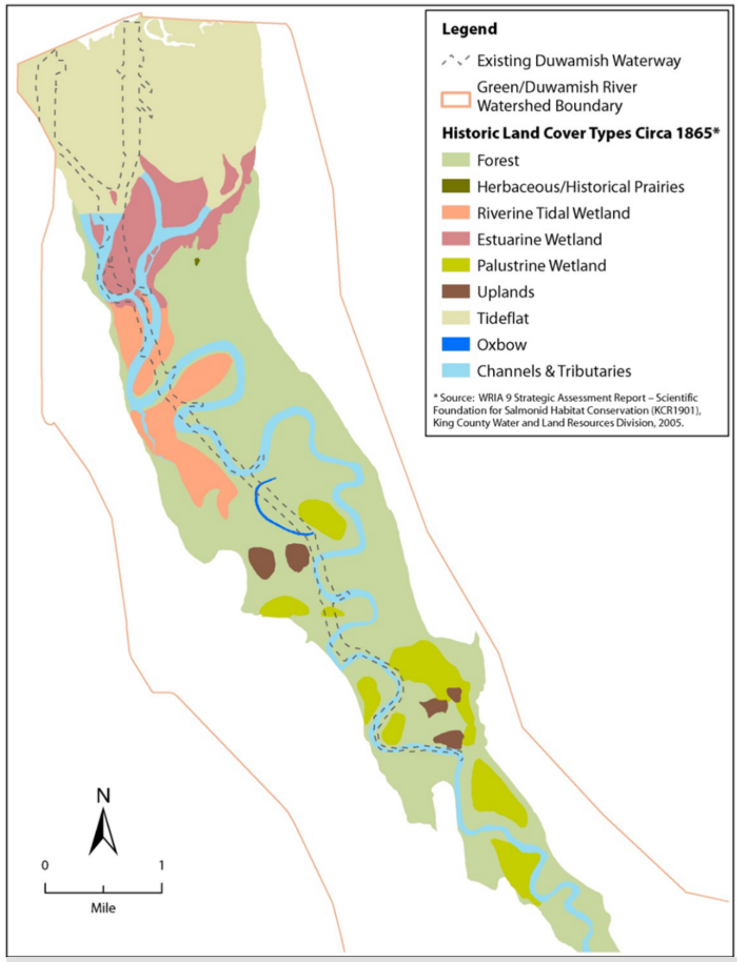

Figure 2-1: Map of former Duwamish estuary habitats. Taken from NRDA Final EIS.

In 1900 the entire estuary consisted of intertidal mud and sand flats, estuarine marsh, forested wetland, and a meandering slow river channel (Figure 2-1). The combined intertidal and

[24] City of Seattle Salmon Team, "Seattle's Urban Blueprint for Habitat Protection and Restoration," 2001.

[25] Watershed Resource Inventory Area (WRIA) 9 Steering Committee, "Salmon Habitat Plan: Making Our Watershed Fit for a King," 2005.

Figure 2-2: Industrial activity and shoreline modifications at River Mile 1.8. Taken from the Port of Seattle's Lower Duwamish River Habitat Restoration Plan (2009).

estuarine floodplain habitat area was approximately 5,300 acres.[26] This habitat functioned as important feeding, spawning, and migratory habitat to native fish and wildlife, including eight species of anadromous salmonids.[27] Urban development in the Seattle area over the last 130 years has dramatically changed the area, altering the hydrology of the Duwamish/Green River basin and nearly eliminating the estuarine ecosystem it once supported. Where once the estuary received the combined flows of three major tributaries covering over one million acres, two of these tributaries were permanently diverted, resulting in a loss of approximately 70 percent of the historic watershed and 90 percent of the historic floodplain.[28] Only eight percent of the former stream spawning habitat is available to migratory fish.

The estuary itself has been largely eliminated over time by the growth of the City of Seattle and associated waterfront development activities. Over 97 percent of the historic estuary area has been filled, armored, or dredged, and by 1986 only two percent of the historic estuarine delta wetlands remained. The Army Corps of Engineers completed channelization of the lower 4.6 miles of the waterway in 1917, converting the stretch of river to an industrial waterway. This

[26] Seaport Planning Group, "Lower Duwamish River Habitat Restoration Plan: An Inventory of Port of Seattle Properties," 2009.
[27] City of Seattle Salmon Team, "Seattle's Urban Blueprint," 2001.
[28] Cordell et al., "Functions of Restored Wetlands for Juvenile Salmon in an Industrialized Estuary," 2011.

stretch is currently almost entirely armored,[29] and 15 percent of the shoreline is covered by overwater structures.[30] The Corps continues to dredge the channel for navigation today, and the LDR is home to the largest urban population and industrial center in the region. Approximately 5,000 acres of land along the LDR is zoned industrial, constituting almost 80 percent of Seattle's industrial land base and generating 80,000 family wage jobs in the city.[31] Facilities lining its banks include marine shipping terminals, manufacturing plants, chemical and solid waste recycling companies, ship repair yards, numerous combined sewer outfalls, and over two hundred storm drains.[32]

In addition to physical loss of habitat, surrounding development and land use have resulted in a highly contaminated estuary. The nature of the contamination has changed from urban and resource-based industrial contaminants at the turn of the century to more complex and toxic contaminant discharges during World War II.[33] These chemicals accumulate in the organisms that live in the benthic sediments of the LDR, making their way into fish that prey on those organisms. Although pollution control regulations and contaminant remediation have significantly reduced waste discharges over the past few decades, remaining contamination has resulted in the estuary being designated a major federal Superfund (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]) site. Although some settlement with potentially responsible parties has occurred, overall settlement and cleanup has not been achieved.[34]

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[29] Morley et al., "Ecological Effects of Shoreline Armoring on Intertidal Habitats of a Puget Sound Urban Estuary," 2012.
[30] Simenstad et al., "Challenges," 2004.
[31] DRCC, "Duwamish Valley Vision Map & Report," 2009.
[32] NOAA, "Final LDR NRDA Restoration Plan and Programmatic EIS," 2013.
[33] Simenstad et al., "Challenges," 2004.
[34] *Ibid.*

2.3.2 Regulatory context and restoration history

Despite the litany of persistent stressors in the Duwamish estuary, restoration of natural shoreline ecosystems in the LDR has become a high priority in the region. Human and financial investment has been exhaustive, and the amount of existing natural habitat on which to build a functioning ecosystem is miniscule. However, the estuary still supports a diverse ecology, with abundant anadromous and resident fish, shellfish, other invertebrates, marine mammals, and birds.[35] Importantly, viable salmon populations still travel through the estuary to and from spawning habitats. The loss, degradation, and fragmentation of estuarine habitat in the LDR is considered a limiting factor for populations of endangered salmonid species in the watershed, including Puget Sound Chinook, bull trout, and steelhead.[36] As a result, federal trustees of the damaged public resources under CERCLA, state resource agencies, non-governmental organizations, and unaffiliated citizenry comprise an active community of restoration advocates who believe in the importance and feasibility of returning some natural functions to the estuary.[37]

Much of the most intensive restoration effort has been driven by regulatory mandate at the federal, state, or local level. Under Section 404, the Clean Water Act requires compensatory restoration for shoreline or in-water development, including dredging of the waterway.[38] Hydraulic Project Approvals, granted by the Washington State Department of Fish and Wildlife (WDFW), and Shoreline Substantial Development Permits, controlled through local Shoreline Master Programs by the Washington State Department of Ecology (Ecology), have similar

[35] Environmental Protection Agency (EPA), "Appendix B: Environmental Justice Analysis for the Lower Duwamish Waterway Superfund Cleanup," 2013.
[36] WRIA 9 Steering Committee, "Salmon Habitat Plan" 2005.
[37] Simenstad et al., "Challenges," 2004.
[38] *Ibid*.

requirements.[39] Taken together, these regulations govern shoreline and in-water development and help ensure a balance between environmental and economic interests in the shore zone.

Restoration activity began in 1988, with many of the most intense efforts driven by the regulatory mandates described above. What were initially single-authority projects gradually evolved into broader partnerships with a variety of governmental and non-governmental entities. Larger, higher-profile mitigation actions were also rapidly followed by grassroots or other non-regulatory restoration efforts. By the mid-1990s, expanded, community-based partnerships began to emerge for non-regulatory restoration, which merged diverse funding sources, resources, and responsibilities. Activities were typically limited to small shoreline projects of 0.25 acres or less, and focused primarily on habitats that provide juvenile salmonids with food, refuge from predation, and brackish waters for osmoregulation.[40] Restoration actions included removal of shoreline armoring and other structures in middle and upper intertidal elevations, excavation of off-channel features, and planting of emergent and riparian vegetation.[41] Examples of more recent and more ecologically complex mitigation projects include Diagonal Marsh, a 0.4-acre embayment excavated into the armored shoreline of the river; and Terminal 105, a 3.6-acre excavation and creation of an off-channel slough and intertidal marsh (Figure 2-3).[42] In general, the location of most projects was based on opportunistic criteria, such as property availability and cost, rather than ecological context.[43] For larger entities such as the Port of Seattle, public access projects – also constructed as mitigation required under local regulations, but for loss of

[39] Washington Administrative Code (WAC) 173-27: Shoreline Management Permit and Enforcement Procedures (2011).
[40] Cordell et al., "Functions of Restored Wetlands," 2011.
[41] Simenstad et al., "Challenges," 2004.
[42] Seaport Planning Group, "Portfolio of Habitat Initiative Projects," 2014.
[43] Cordell et al., "Functions of Restored Wetlands," 2011.

public shoreline access – provided an opportunity to incorporate small habitat elements such as riparian vegetation (Figure 2-4).[44]

Figure 2-3: Port of Seattle restoration site at Terminal 105. Taken from the Port of Seattle's Lower Duwamish River Habitat Restoration Plan (2009).

Figure 2-4: Port of Seattle public access park at Terminal 107. Taken from the Port of Seattle's Lower Duwamish River Habitat Restoration Plan (2009).

Duwamish CERCLA actions began appearing in 2000 and expanded the dimension and distribution of restoration sites throughout the estuary. In addition to the cleanup of contamination, the Superfund law establishes liability for damages to natural resources such as valuable fish and wildlife species and their habitat. This portion of the Superfund program, known as the Natural Resource Damage Assessment (NRDA) and Restoration Program, is implemented by Natural Resource Trustees, which for the LDR include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service, Ecology, WDFW, the Suquamish Tribe of Indians, and the Muckleshoot Indian Tribe.[45] The Trustees assess the extent of natural resource damages and bring claims against responsible parties to recover those damages. In the LDR, potentially responsible parties (PRPs) include the Port of Seattle, the City of Seattle, King County, and the Boeing Company. Given the resources available and the impetus of federal legal action, NRDA

[44] *Ibid.*
[45] Seaport Planning Group, "Lower Duwamish River Habitat Restoration Plan," 2009.

projects tend to be larger and more complex than previous mitigation efforts. Examples include the City of Seattle's Herring's House, a 15.5-acre intertidal wetland, and the Port of Seattle's 10.7-acre project at Terminal 117. Figure 2-5 shows a map of planned and completed restoration projects in the LDR to date.

2.3.3 Socioeconomic context

In addition to industry and habitat, the LDR supports other important uses such as fishing, recreation, and shoreline access for surrounding residents. The Duwamish Valley is home to some of the most ethnically diverse residents in the Seattle area. In Seattle, the neighborhoods of South Park and Georgetown are adjacent to the river, with segments of several other neighborhoods within a one-mile radius. These include Delridge, Highland Park, SODO, and High Point. Residents identifying as non-white or multiracial comprise 66 percent of the South Park population, as compared to a Seattle average of 30 percent.[46] Throughout the Duwamish Valley, residents speak more than 30 native languages.[47] Both South Park and Georgetown also have emerging artist and small business communities; Georgetown in particular is known for its density of artists' studios.[48] The Valley is also home to some of the poorest communities in the Seattle area. In South Park, one in five children lives below the poverty line; in High Point, the rate is closer to 47 percent, giving the neighborhood once of the highest children's poverty rates in the city.[49] The combination of diversity, culture, and poverty has generated concern about impending gentrification and associated rising housing prices, dislocation of existing low-income families, and loss of community character.[50]

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[46] DRCC, "Duwamish Valley Vision Map & Report," 2009.
[47] *Ibid*.
[48] EPA, "Environmental Justice Analysis," 2013.
[49] DRCC, "Duwamish Valley Vision Map & Report," 2009.
[50] *Ibid.*

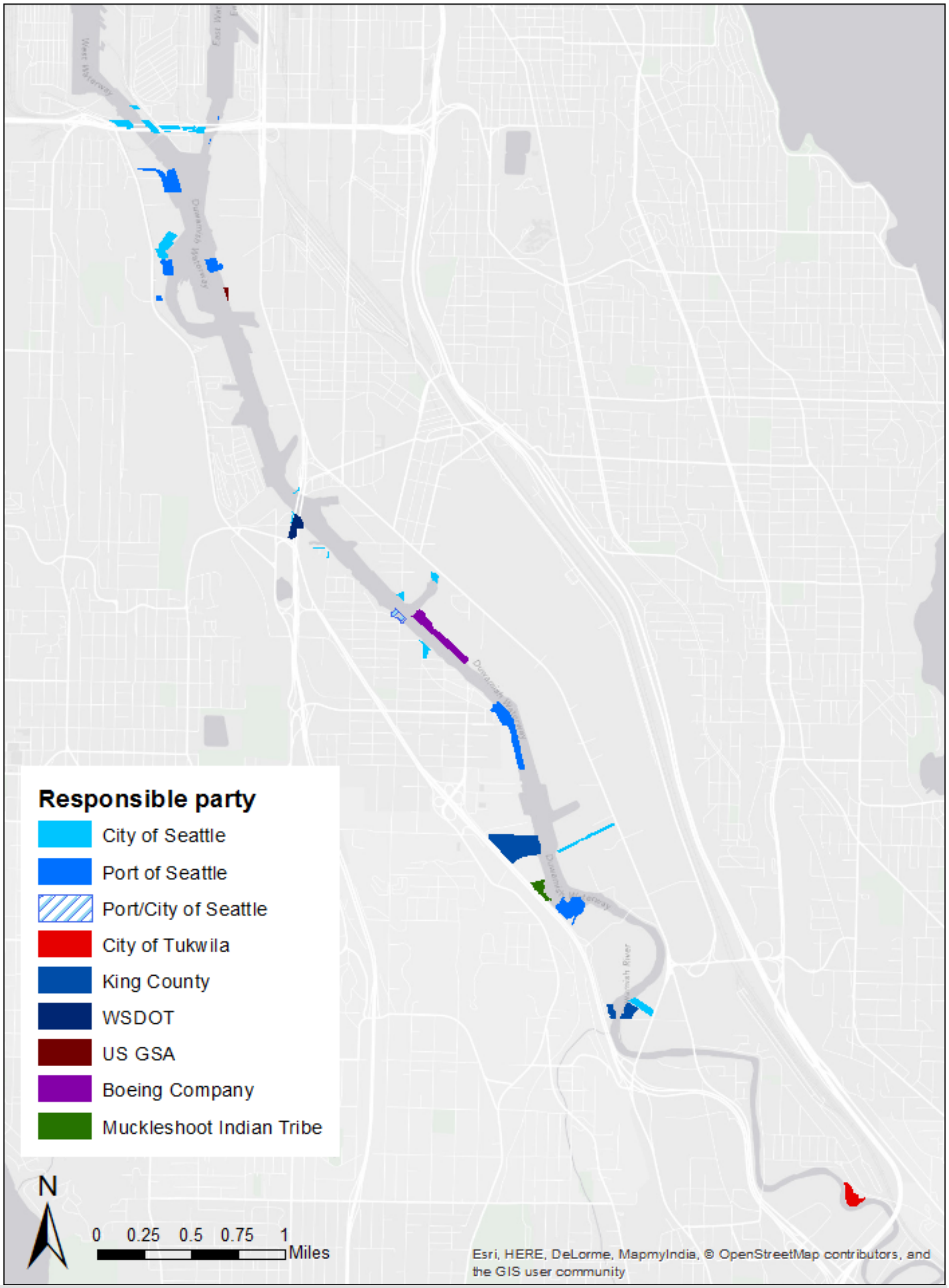

Figure 2-5: Map showing habitat restoration projects completed or planned in the LDR, color-coded by responsible party.

Just south of Seattle, the City of Tukwila flanks the LDR on both sides. The city is home to fewer than 20,000 residents, but also supports diverse communities as well as a large commercial center that draws workers and consumers to the city.[51] Land uses along the LDR are primarily residential, and therefore feature less urban development than LDR neighborhoods in Seattle. Residential developments along the LDR are a mix of industrial, urban, and suburban, and are generally lower income than the rest of the city.[52]

Other segments of the community that share the Duwamish Valley with its Seattle and Tukwila residents include industrial businesses, recreational users, and tribal and subsistence fishermen. Several marinas serve both recreational boaters and permanent houseboat residents, and numerous boat ramps and hand boat launches provide shoreline access to small vessels of all kinds. A substantial transient and homeless population encamps along the LDR, and several predominantly Asian and Pacific Islander immigrant groups are known to harvest a variety of seafood from the river.[53] The federally-recognized Muckleshoot and Suquamish tribes have historical treaty rights to harvest fish and shellfish from the river. The Muckleshoot Tribal Fishery, an active salmon fishery, is headquartered on the LDR. The Duwamish tribe also remains a presence in the area, using Herring's House Park for cultural ceremonies. The tribe also recently built a Duwamish Longhouse located across from Terminal 107 Park. Tribal access to fish and shellfish along the LDR is not just a matter of consumption, but of culture. Until the 1850s, the LDR served resident Native Americans as a transit corridor, spiritual haven, and a protected place to gather salmon, other fish, and shellfish, as well as plants, berries, and other subsistence resources.[54]

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[51] City of Tukwila, "Comprehensive Land Use Plan," 2011.
[52] *Ibid*.
[53] DRCC, "Duwamish Valley Vision Map & Report," 2009.
[54] EPA, "Environmental Justice Analysis," 2013.

Among residents, fishermen, and industrial businessmen within the Duwamish Valley, support for habitat restoration along the river is varied. While industry and tribal fishing interests are often concerned with potential negative impacts on business, in general the concept of a sustainable coexistence between an urbanized, industrial economy, thriving urban residential neighborhoods, and a naturally functioning estuarine ecosystem has become a feasible goal for Duwamish Valley stakeholders.[55] A restoration constituency has evolved among the local and regional community, which views restoration as an investment in community assets, including reducing human health risks, increasing recreational opportunities, and sharing the history, culture, and social role of the estuary.[56] Community festivals are held regularly at riverfront parks, with the annual Duwamish River Festival at Duwamish Waterway Park being the largest. Numerous community groups are involved with small-scale restoration on a grassroots, voluntary basis, and since 2006 the Duwamish Alive Coalition has brought more than 30 of these groups together to coordinate protection and restoration of the river "for both wildlife and communities."[57]

The stakeholder communities along the LDR are involved in several planning efforts that are relevant to restoration as well. The Washington State Growth Management Act directs local jurisdictions to develop comprehensive plans and regulations for growth and development, with required involvement of the public.[58] In 1995, to address population growth, the City of Seattle began incorporating neighborhood planning into their comprehensive plan process. Each neighborhood plan reflects a community's vision for its future, including its relationship with the environment. Municipal open space and recreation planning is also part of the comprehensive

[55] DRCC, "Duwamish Valley Vision Map & Report," 2009.
[56] Simenstad et al., "Challenges," 2004.
[57] "Duwamish Alive: Restore Our River!," Duwamish Alive, accessed June 4, 2014, http://duwamishalive.org.
[58] Revised Code of Washington (RCW) Chapter 36.70A: Growth Management – Planning by Selected Counties and Cities (2011).

plan process, and addresses the specific needs of each community for different kinds of open space. Habitat restoration, designation of critical areas, and environmental conservation are often elements of these plans.[59] Finally, the Washington State Shoreline Management Act directs jurisdictions to develop Shoreline Master Programs (SMPs) that lay out plans, policies, and regulations for shoreline development. These SMPs must reflect the jurisdiction's vision for its shoreline, while balancing the interests of the environment, waterfront businesses, and public shoreline access.[60] Compared to small community-driven efforts, these planning efforts are more similar in scope and to the ecological planning efforts mentioned previously. They therefore present an opportunity for integration or collaboration with these ecological plans, and alignment of restoration goals for the LDR.

2.4 Purpose of this research

There are many valid reasons to restore nearshore and shoreline habitat in an urban estuary. Some of these reasons are obvious and include, for example, environmental quality and recovery of valued fish populations. Other reasons may be more obscure and less tangible, such as direct or indirect social benefits, but these are often equally important.[61] Defining restoration goals and objectives is fundamentally a value-based, not scientific, exercise, and should be derived from a complex mix of ecological, social, historical, and philosophical viewpoints.[62] Recommendations for particular courses of action need to be prioritized so that restoration projects can achieve the best possible result within the constraints of an urban setting.[63] In the face of numerous and dynamic players and extreme constraints, restoration in the LDR must be

[59] Interagency Committee for Outdoor Recreation, "Planning for Parks, Recreation, and Open Space in Your Community," 2005.
[60] Washington State Department of Ecology (Ecology), "Shoreline Master Program (SMP) Handbook," 2012.
[61] Findlay and Taylor, "Why Rehabilitate Urban River Systems?," 2006.
[62] Miller and Hobbs, "Habitat Restoration," 2007.
[63] *Ibid.*

strategic in order to succeed in the long-term. Restoration planning efforts must balance real ecological limitations with the potential for significant social value in order to design projects appropriate to this unique historical, cultural, and physical setting.

Many groups of scientists in the region have developed plans for prioritizing habitat restoration in the LDR based on ecological criteria. Numerous community planning efforts have generated goals for sustainable, livable neighborhoods in the same region. None of these efforts is more valid or important than the others. At the same time, the best way to incorporate or understand social value is to have it defined directly by the society it is intending to serve.[64] My approach is to resolve the ecological and social goals defined in these plans, leveraging the good planning work that has been done by scientists and community members. The goal of this approach is to facilitate selection of habitat restoration projects in the LDR such that those projects maximize both ecological and social benefits to the region. Including community priorities together with scientific ones in restoration decision-making will ensure social acceptance and the ecological benefits that follow from it.

Due to the constraints of the urban setting, the primary parties performing restoration in the LDR are large, primarily public, institutions with regional influence and authority. In several cases, these institutions also own a significant portion of the waterfront property in the LDR.[65] At the same time, the regulatory context of the area results in a system-scale approach to restoration planning. For example, the Port of Seattle operates numerous industrial properties within the LDR, the development of which require extensive permitting and compensatory restoration. Rather than address these requirements as they arise, the Port develops long-range

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[64] Eden and Tunstall, "Ecological Versus Social Restoration? How Urban River Restoration Challenges But Also Fails to Challenge the Science-Policy Nexus in the United Kingdom," 2006.

[65] Seaport Planning Group, "Lower Duwamish River Habitat Restoration Plan," 2009.

plans that predict and account for future development and associated habitat needs.[66] The greater scale, influence, and resource availability associated with these larger institutions provide some flexibility in restoration planning relative to one-off, community based projects. The biggest decision facing many of these institutions is where to locate restoration projects. While this decision is often based on economic or feasibility considerations, it can also be the greatest determinant in the ultimate value of the project. Therefore, this research is intended to inform the site selection process for the institutions planning for and performing habitat restoration in the LDR.

[66] *Ibid.*

3 Research design

3.1 Research questions

As discussed above, the goal of this research is to facilitate strategic selection of habitat restoration projects in the LDR, such that those projects can maximize both ecological and social benefits. To accomplish this, the research was broken down conceptually into three problems that are operationalized by three corresponding research questions:

1. Problem: How can the ecological benefits of shoreline and nearshore restoration be maximized in the LDR?

   Research Question (RQ1): In the LDR, what characteristics of shoreline and nearshore habitat restoration contribute to ecological value, and how?
2. Problem: How can the social benefits of shoreline and nearshore restoration be maximized in the LDR?

   Research Question (RQ2): In the LDR, what characteristics of shoreline and nearshore habitat restoration contribute to social value, and how?
3. Problem: Where is total potential restoration value in the LDR maximized?

   Research Question (RQ3): How do the characteristics from RQ1 and RQ2 vary in space throughout the LDR?

Taken together, the answers to the first two research questions provided the foundation for a conceptual model of restoration value in the LDR. This model was then applied using spatial analysis in order to answer the third question. The entire process is described in the following section.

3.2 Methodology

3.2.1 Overall approach

My overall approach is broken down into two phases. Phase One addresses RQ1 and RQ2, while Phase Two addresses RQ3. In Phase One, I characterized how stakeholders in the LDR define ecological and social value through systematic analysis of the plans produced by those stakeholders. This analysis included summarizing how the various plans discussed or defined ecological and social value, and the characteristics that contributed to or decreased that value. The output of this analysis was a conceptual model of ecological and social value in the LDR. I then used this conceptual model together with a set of rigorous criteria to develop a collection of metrics. Each metric is linked directly to one or more characteristics that were identified in the plans as bringing ecological or social value to any potential restoration project in the LDR. In this way, they are a representation of the region's goals and priorities for restoration. In Phase Two, I used spatial analysis to calculate metric values for potential restoration sites (waterfront parcels) along the LDR. I then applied a linear additive model to combine metric values into overall ecological and social index values for each parcel. The output of this process was a series of maps showing the spatial distribution of potential ecological and social value for potential restoration sites along the LDR.

3.2.2 Relationship to other approaches

My approach yields an understanding of relative ecological and social value among parcels; it does not attempt to design or calculate absolute measures of value, as a financial study in ecosystem service valuation might. The output of my analysis is intended to support the informed selection of the "best" site for restoration among a collection of potential sites. In this respect, it is similar to many other efforts to evaluate, compare, and prioritize options for restoration based on multiple variables or objectives.

Some of the efforts to prioritize options for restoration in the Puget Sound region formed the scientific foundation for several of the plans included in my analysis. Stanley et al., 2005, based prioritization on degradation of individual ecosystem processes.[67] The processes were then evaluated as a whole to establish shoreline characterizations at the reach and sub-reach scale that defined the relative degree of degradation of shoreline ecological functions. These characterizations are most appropriate at a watershed scale, and were used to develop strategies for protection, restoration, or enhancement in Shoreline Master Programs.[68,69] A similar approach was used by the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) to develop Sound-wide strategies (Figure 3-1).[70]

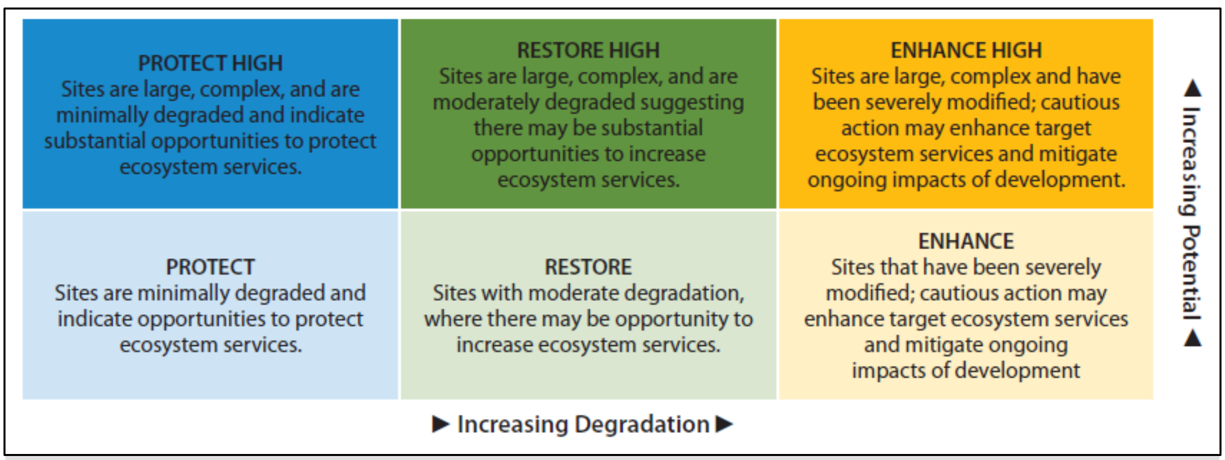

Figure 3-1: Recommendations based on degree of degradation and relative potential for restoration success. Taken from Cereghino et al. 2012.

[67] Stanley et al., "Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes," 2005.
[68] City of Seattle, "Shoreline Master Program," 2012.
[69] King County, "King County Comprehensive Plan, Chapter 5: Shorelines," 2012.
[70] Cereghino et al., "Strategies," 2012.

As shown in the figure above, the PSNERP approach also considers likelihood of restoration success. This is an important and widely-considered factor throughout the restoration community.[71] Roni, 2003, developed a hierarchical prioritization scheme that incorporates likelihood of success, feasibility, and cost, and that has been adopted by several smaller restoration efforts throughout Puget Sound.[72] Indeed, due to land constraints and the limited availability of funds, most restoration prioritization schemes incorporate feasibility considerations to some degree.[73] An effort that does not consider feasibility and that is perhaps most similar to my approach is the Washington State Department of Fish and Wildlife (WDFW) Puget Sound Watershed Characterization. Rather than adopt a hierarchical prioritization scheme, WDFW used an index to reduce a complex, multi-dimensional system down to a single number, thereby facilitating planning and policy decisions.[74] The characterization project assessed the relative value of potential sites for the conservation and restoration of habitat, basing scores on existing habitat characteristics (Figure 3-2).[75] In my approach to the LDR, WDFW's existing habitat characteristics are ecological and social metrics, and sites A through D are the collection of waterfront parcels.

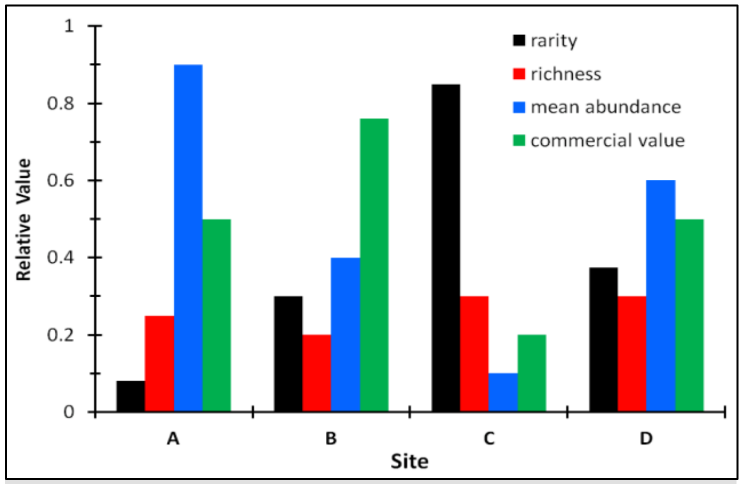

Figure 3-2: Graph showing relative value scores on four habitat characteristics for four potential sites. Taken from Wilhere et al. 2013.

[71] *Ibid.*
[72] Roni et al., "Prioritizing Restoration Actions Within Watersheds," 2003.
[73] WRIA 9 Steering Committee, "Salmon Habitat Plan" 2005.
[74] Wilhere et al., "A Coarse-Scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines," 2013.
[75] *Ibid.*

Timm et al., 2004, went one step further, incorporating anthropogenic factors such as real estate value and zoning into their multi-criteria index. However, unlike in my approach to the LDR, these factors represented ecological value and feasibility considerations, rather than social value.[76]

The examples above all have an emphasis on ecological value. Analogous prioritization schemes aimed at maximizing social value are much less common. Instead, those wishing to evaluate potential value might focus on indices or metrics for individual characteristics. For example, Che et al. 2012 applied the Comprehensive Index of Public Accessibility of Riverfront (CIPAR) to the Suzhou Creek and its distributaries in Shanghai, China. The index combines both characteristics of and associated benefits of accessibility, including spatial accessibility, visual accessibility, corridor continuity, and "indicators of amenity."[77] As with the social value metrics developed for the LDR, the CIPAR index can be used to evaluate relative suitability of sites for introducing open space or restoration. A similar effort by Tapsuwan et al., 2012, developed a model for estimating hedonic land value based on variables of "recreational attractiveness," including available park facilities and recreational activities offered at each site.[78] Page, 1997, expanded on both of these efforts to create a more comprehensive estimation of both physical and social barriers to access, including demand for open space and supply of human resources.[79] However, rather than informing site selection of new open space, these efforts were all applied retroactively to existing parks, open spaces, and restoration sites. For selecting new sites for open space, government agencies instead often turn to static, system-wide goals. Many follow guidelines developed by the National Recreation and Park Association (NRPA) for different

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[76] Timm et al., "A Screening Procedure for Prioritizing Riparian Management," 2004.

[77] Che et al., "Assessing a Riverfront Rehabilitation Project Using the Comprehensive Index of Public Accessibility," 2012.

[78] Tapsuwan et al., "A Combined Site Proximity and Recreation Index Approach to Value Natural Amenities," 2012.

[79] Page, "Predicting the Social Impacts of Restoration in an Urban Park," 1997.

types of open space. For example, the NRPA suggests 10 acres of resource conservancy land for every 1,000 people.[80] The City of Seattle has set a city-wide goal of a public shoreline access point every half-mile.[81] These types of standards, while only indirectly informing site selection, point to the more general objective that, to maximize social value, open spaces and restoration sites be designed and located to facilitate interaction with people.

These efforts reveal a large and diverse collection of rules, criteria, preferences, and priorities used to decide where and how to perform restoration. Practically, each restoration effort has a unique set of functional requirements and constraints, and these will guide not only site selection but the ultimate ecological and social value of the completed project. "There is unlikely to be a generic set of recommendations that is applicable everywhere because actions need to be matched to the particulars of the site and situation."[82] However, all restoration efforts should develop appropriate goals that are directly linked to restoration objectives for the region.[83] My approach distills criteria from the plans that were prepared specifically by and for those that live, work, and plan in the LDR. These criteria therefore become a reasonable representation of what local scientists, community members, and other stakeholders believe is best for the area. By nature of their regulatory authority, these plans also shape the present and future of restoration and open space in the LDR. Unlike the efforts described above, my approach leverages the quality planning work that has been completed for the LDR as input into restoration decision-making.

[80] City of Tukwila, "Parks, Recreation, and Open Space Plan," 2008.
[81] Maggie Glowacki, e-mail message to author, 2012.
[82] Miller and Hobbs, "Habitat Restoration," 2007.
[83] *Ibid.*

3.2.3 Phase One: Regional plan analysis

3.2.3.1 Selection of plans

No single regional plan or prioritization effort defines value only in ecological or social terms. Instead, most plans discuss both to some degree, with any site-level prioritization efforts almost always incorporating some consideration of feasibility in addition to ecological and/or social metrics. This widespread use of feasibility metrics reflects the opportunistic nature of restoration efforts discussed previously. In an effort to get at a true understanding of the potential value of restoration in the LDR, I omitted such feasibility considerations from my analysis and looked only to ecological and social considerations. In order to do this I collected plans that, through pursuit of a particular goal, directly or indirectly defined ecological or social value in the LDR. Ecological plans were defined as those with a primary goal stated explicitly to address an ecological problem or to contribute to an ecological agenda. Examples of ecological goals include recovery of salmon populations, restoration of lost fish and wildlife habitat, or recovery of damaged natural resources. Social plans were defined as those with a primary goal stated explicitly to address a social, socioeconomic, or cultural problem or to contribute to a social, socioeconomic, or cultural agenda. Examples of social goals include increasing public shoreline access, increasing urban open space, or creating livable neighborhoods. Shoreline Master Programs were included as both ecological and social plans, with stated goals (as mandated by the SMA) to balance social, economic, and environmental objectives.

In curating this collection, my objective was to be as comprehensive as possible while ensuring that the plans are and will continue to be relevant to restoration planning in the LDR. In order to accomplish this objective, I selected both ecological and social plans for inclusion in the analysis using a set of criteria. These criteria are defined as follows:

- *Planning process.* Plans must have completed, and documented, a formal planning process. For ecological plans, this may include an inventory or prioritization of shoreline stretches, specific sites, or both, based primarily on ecological criteria. For social plans, this includes a formal planning process with public involvement. In both cases, this requirement is intended to ensure that the plan reflects a rigorous consensus among the community it represents. This requirement is particularly relevant because of the nature of the research it supports, which is a form of prioritization itself.
- *Based on documented methods or information.* Ecological plans must document use of best available science. For social plans this requirement is less well defined, though in general they must refer to standards or practices that are either accepted by their relevant community or mandated by the same authority mandating the development of the plan itself. For example, Shoreline Master Programs must follow the shoreline designation guidance provided by Ecology.
- *Regulatory relevance.* Plans must have been developed as the direct requirement of a federal, state, or local regulation. Similarly, plans must have some form of implementation authority. The implementation mechanism itself can be direct, indirect, operational, financial, or advisory. This requirement ensures that the selected plans, as a collection, comprise the framework within which restoration projects are currently developed and built in the LDR.
- *Appropriate scale and geographic extent.* The focus area and scale of each plan must be appropriate to the scale of restoration in the LDR, which ranges from the parcel level to the entire LDR.[84] This precludes inclusion of site-scale plans, while also ensuring a more locally-specific analysis separate from statewide or larger planning efforts. This

[84] Wilhere et al., "A Coarse-Scale Assessment," 2013.

requirement ensures a spatial match between the analysis of the plans and the broader goals of this research.

These criteria narrow the scope of the analysis to include the parties working, living, and planning in the LDR and Duwamish River Valley now and for the next 20 to 50 years. While the resulting analysis is comprehensive in that respect, it does exclude significant scientific work done both by the academic community and by state and regional public agencies and organizations. Some of this is incorporated into the ecological plans as "best available science." The rest was used as independent verification for the metrics developed from the analysis.

Application of these criteria to the larger collection of plans and documents relevant to restoration in the LDR yielded a final collection of 10 plans, including two ecological plans, three ecological and social plans, and five social plans. These are listed in Table 3.2-1 below.

Table 3.2-1: Final list of plans included in regional plan analysis

Plan	*Year*	*Focus*
NRDA Final EIS and Restoration Plan for the LDW	2013	Ecological
WRIA 9 Salmon Recovery Plan	2005	Ecological
Seattle Parks and Recreation Open Space Plan	2011	Social
Tukwila Parks, Recreation, and Open Space Plan	2008	Social
SDOT Shoreline Street Ends Program	2009	Social
Seattle Neighborhood Plans (Georgetown, South Park, Delridge, and Manufacturing and Industrial Center)	1998-2008	Social
Duwamish Valley Vision Report	2009	Social
City of Seattle Shoreline Master Program	2011	Both
City of Tukwila Shoreline Master Program	2009	Both
King County Shoreline Master Program	2010	Both

3.2.3.2 Analysis and conceptual model development

Analysis of the 10 plans involved reading through each plan with the intention of answering one or both of my first two research questions. Practically, including both ecological and social plans in the analysis resulted in extremely diverse vocabulary and treatment of the concept of a "restoration project." For example, restoration projects may incorporate elements of human habitat, such as boat ramps or walkways, to varying degrees. Such elements increase the social value of a restoration project.[85] Conversely, plans may focus primarily on creation of open spaces that may incorporate ecosystem restoration elements to varying degrees. In general, the degree to which such elements are incorporated is addressed during site design, at the site scale. This is after site selection has occurred, and therefore later in the planning process than this research intends to address. Indeed, my research aims to identify what characteristics give a site more or less *potential* ecological or social value than another site, given similar site design.

Therefore, in reading through plans to extract value statements, the effective research question I asked was: "How does this plan define ecological and/or social value with respect to the LDR shoreline environment?" For each plan, this involved:

- Describing the planning framework behind the plan, including any standards developed or adopted from outside sources;
- Describing any prioritization schemes, including at the regional, river stretch, or site scale; and
- Describing any metrics or characteristics, spatial or otherwise, and their role in determining ecological or social value or priority as defined by the plan.

These descriptions were analyzed to extract general trends, similarities, and differences in the way the plans described ecological or social value. All of this information was then used to develop a conceptual model of ecological and social restoration value in the LDR. The result of this process is discussed in Section 4.1.

[85] Tapsuwan et al., "A Combined Site Proximity and Recreation Index Approach," 2012.

3.2.3.3 Definition of metrics

An initial list of metrics was developed based on the plan analysis. Metrics, in the form of characteristics that bring value to a restoration site, could be defined in each plan explicitly or implicitly. For example, ecological plans that include site-scale prioritization schemes would list the criteria underlying such schemes; these criteria would then be included in the initial list of metrics. Social plans, on the other hand, might describe broader objectives or conceptual models of preferred open space. From such plans, metrics were extracted through analysis of these conceptual models and their implications – in other words, the value judgments they expressed implicitly.

My objectives for this process were to select simple and powerful metrics that would be rigorous and meaningful, but also easily understandable by those practitioners making restoration decisions in the LDR. The metrics should preserve as much information as possible and minimize subjectivity. Taken together, they should reveal the spatial distribution of the potential ecological or social value of restoration in the LDR. In order to accomplish these objectives, development of metrics was guided by an explicit set of criteria. These criteria are defined as follows:

- *Supported by academic literature.* This requirement provides a sanity check for metrics derived solely from regional planning documents. Support from the scientific restoration community ensures that metrics will be rigorous and defensible, and therefore more useful to decision-makers for a wide range of applications.

- *Not accounted for by another metric.* This requirement prevents double-counting when estimating overall ecological or social value. It is derived from guidance provided by Ecology on the development of indicators.[86]
- *Relevant to the regulatory authority of organizations performing restoration.* This requirement removes variables from consideration if they are outside of the reasonable sphere of influence of the organizations performing restoration in the LDR. It is derived from guidance provided by Ecology on the development of indicators.[87]
- *Varying within the study area.* The goal of this research is to inform strategic selection of habitat restoration projects in the LDR. Metrics that do not vary in value throughout the LDR do not provide useful information for those selecting between potential restoration sites in the LDR.
- *Appropriate spatial scale.* As discussed in the previous section, restoration projects can vary in social value based on site-specific design features such as walkways, boat ramps, or public restrooms. Similarly, site-specific habitat features, such as relative sizes of mudflat, marsh, and riparian area, can increase or decrease the ecological value of a restoration project on a given site. This requirement excludes such site-specific design considerations, focusing the analysis instead on LDR-scale site selection. This requirement also effectively excludes metrics without a spatial component, such as community outreach or educational programming. Instead, I assume that, following site selection, it is up to the organization performing the restoration to maximize the actual value of the project through manipulation of these features.

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[86] "Avoid choosing several indicators that may represent the same impacts on ecological function." Ecology, "Shoreline Master Program Handbook," 2012, Chapter 4 p. 18.
[87] "Indicators should be relevant to the regulatory authority that our local government has over factors that affect the indicators." Ecology, "Shoreline Master Program Handbook," 2012, Chapter 4 p. 16.

- *Operational.* This requirement ensures that metrics can be calculated using available data and spatial analysis methodology.

One final assumption limited my selection of metrics. Though several plans mentioned both water quality and sediment contamination as considerations for site selection, I do not include them as metrics. As discussed previously, the northern five-mile stretch of the LDR has been designated as a Superfund site and is currently undergoing a formal remediation process, led by the U.S. EPA and Ecology. This process has serious implications for the LDR as a whole, including potential negative social externalities of the cleanup activities. I assume that any site will be cleaned up prior to restoration construction, and therefore treat all sites as equivalent in terms of contamination.[88] Using the above criteria together with this assumption, I reduced the initial list of metrics down to six ecological metrics and eight social metrics. These are described in Section 4.2.

3.2.4 Phase Two: Spatial analysis

Spatial analysis was performed using Esri's ArcGIS software, including ArcMap and ArcCatalog. The process involved defining the study area and resolution; operationalizing metrics; digitizing data; calculating and assigning ranks for each metric; and finally weighting the metrics to establish a single index each for ecological and social value. This process is described in the following sections.

3.2.4.1 Defining the universe

For the purpose of this analysis, the study area was defined as the Lower Duwamish River. More specifically, analysis was limited to an 11-mile stretch of the river between the northern tip of Harbor Island, where the LDR empties into Elliott Bay; and a point 11 miles

[88] EPA, "Proposed Plan for Lower Duwamish Waterway Superfund Site," 2013.

upstream in the City of Tukwila. This point represents the upstream limit of saltwater influence, and is therefore a natural boundary for restoration of estuarine habitat in the LDR.[89]

The spatial analysis evaluated the relative ecological and social value of potential restoration sites within the study area. A "potential restoration site" – the analysis unit – was defined as any waterfront parcel on the LDR. Though many restoration sites completed in the LDR to date occupy only a portion of a parcel, this was the smallest unit feasible for this analysis. Land ownership is one of the first and often most important considerations for organizations restoring habitat in the LDR, making ownership boundaries a natural divider.[90] Furthermore, organizations may restore habitat on a parcel in stages, as land becomes available, with full build-out being the ultimate goal.[91] Therefore the values calculated in this analysis are based on the assumption that restoration projects will use as much of the parcel as possible.

Waterfront parcels were defined as those intersecting the LDR shore zone, a 200-foot-wide buffer extending landward from the ordinary high water (OHW) mark on the river. Several parcels were found to intersect the shore zone but not directly abut the shoreline (in other words, non-waterfront parcels); these were included in the analysis if owned by the same landowner in possession of the adjacent waterfront parcel. King County Parcel Viewer 2.0 was used to establish land ownership.[92] Additionally, if a non-arterial public road was the only thing between a non-waterfront parcel and the shoreline, the parcel was included in the analysis. All other non-waterfront parcels were excluded from the analysis. This resulted in 511 parcels included in the analysis (Figure 3-3).

[89] WRIA 9 Steering Committee, "Salmon Habitat Plan" 2005.
[90] *Ibid.*
[91] Seaport Planning Group, "Portfolio of Habitat Initiative Projects," 2014.
[92] King County, "King County Parcel Viewer 2.0," 2013.

The areas that contribute to the potential ecological or social value of a particular parcel extend beyond that parcel's boundary. For both ecological and social metrics, this area was defined as the extent of the Lower Duwamish River Valley. According to the Duwamish River Cleanup Coalition (DRCC), this valley extends south from downtown, and from the West Seattle ridge in the west to the Interstate 5 highway and Beacon Hill in the east.[93] For ease of analysis this area was approximated by a one-mile buffer around the LDR shoreline (Figure 3-3).

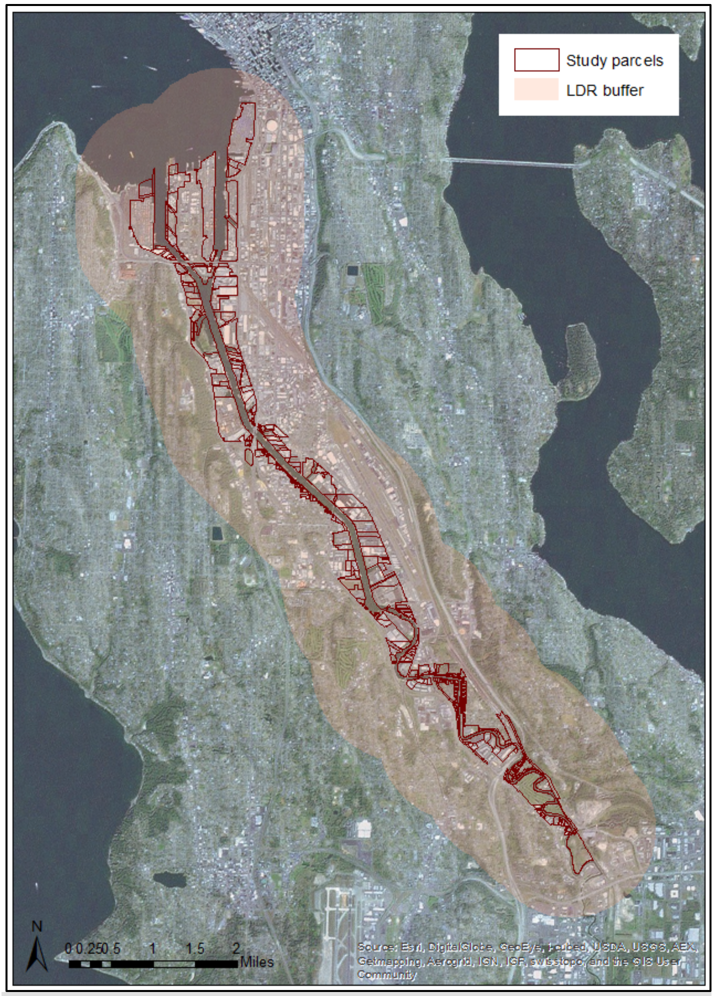

Figure 3-3: LDR study area, including 511 waterfront parcels and one-mile river buffer.

The area encompasses the entirety of Seattle's marine industrial corridor, including the LDW Superfund area. It also includes several urban Seattle neighborhoods that lie immediately adjacent to industrial land, as well as lower density residential areas in Tukwila and unincorporated King County. These areas are home to LDR stakeholders, to whom the social benefits of restoration in the LDR apply.

[93] DRCC, "Duwamish Valley Vision Map & Report," 2009.

3.2.4.2 Operationalizing metrics

In order to prepare the metrics for calculation, I first defined them in terms of spatial analysis. I developed a methodology for each, defining input data types, ArcMap functions and tools used, output data types, and sequencing. Wherever possible, I used elements in the spatial analysis – standard distances, buffer widths, thresholds, etc. – directly from the plan analysis. Where no such standards existed, I developed elements that incorporated information from the plan analysis indirectly, and that were appropriate to the availability and resolution of the input data. Spatial analysis methodology specific to each metric is described in Section 4.2, and models are included at the end of this document as Appendix A.

3.2.4.3 Calculating metrics

After developing methodology models for each of the metrics, I collected the input data necessary to calculate each. There was significant overlap in the data sets needed for each metric. Sources of digital data included the Washington State Geospatial Data Archive (WAGDA), the King County GIS Portal (KCGIS), the Port of Seattle's GIS database, Ecology, the U.S. Census Bureau, the PSNERP Change Analysis database, and the DRCC Valley Vision Report data (provided by Michele Savelle). For input data not available in digital form, I digitized points, polylines, and polygons using satellite imagery and maps from the plans included in the plan analysis. The final collection of data included point, polyline, and polygon vector data types. The complete data dictionary is included at the end of this document as Appendix B. I then calculated each metric according to its methodology model, storing each calculated value as a separate attribute assigned to the collection of study parcels.

3.2.4.4 Multi-criteria decision analysis

The raw metric values represent the lowest level, and therefore most complete, information produced from the spatial analysis. They allow evaluation of each parcel relative to every other parcel along multiple (14) dimensions. Any of these metrics or combinations of metrics could be used by a decision-maker who has clear restoration objectives or priorities, or who is selecting between only a few sites. However, answering my third research question requires developing a way to evaluate all metrics together using the same scale, and then combining those normalized metrics into overall rankings for potential ecological and social value.

Multi-criteria decision analysis (MCDA) provides a method to aggregate multiple decision variables in a meaningful way. Its goal is to provide an overall ordering of options. Due to the nature of multi-criteria problems, no one option will maximize every criterion, and MCDA can bring to light necessary trade-offs between options.[94] Applied to restoration site selection in the LDR, maximizing ecological value might require a trade-off between locating the project next to an existing habitat site and providing habitat in an area that lacks it. MCDA is broadly used by natural resource managers to solve complex problems, including site selection.[95]

I applied MCDA to the 14 ecological and social metrics using a simple linear additive model. This type of model has a well-established record of providing robust decision-making support for a wide range of problems; indeed, most MCDA approaches use this type of model.[96] In order for a problem to be appropriate for use with a linear additive model, its criteria must meet several conditions, including completeness; lack of redundancy; operationality; mutual

[94] Department for Communities and Local Government (DCLG), *Multi-Criteria Analysis: A Manual, 2009.*
[95] Timm et al. 2004; Boysen et al. 2012; Zucca et al. 2008; Van Haaren and Fthenakis 2011; etc.
[96] DCLG, *Multi-Criteria Analysis*, 2009.

independence of preferences; and lack of double-counting.[97] While I did not test them explicitly for independence, the metrics I developed for ecological and social value were finalized using a similar set of conditions (see Section 3.2.3.3 above). Given these conditions and the purpose of its application, I judged MCDA to be appropriate for use with these metrics.

Combination of multiple criteria in a linear additive model involves multiplying the value of each criterion by the weight of that criterion, then adding those weighted scores together.[98] In order to prepare the metric values for weighting and combination, I first converted them all to an ordinal level of measurement. I did this by assigning a rank value between one and five to each raw metric value, resulting in five classes, with a rank of five representing the highest potential ecological or social value for that metric. Ranks were determined by the range of raw values for each metric. For continuous (ratio) data, the raw value ranges within each rank were assigned using natural breaks (jenks). For interval data, I created equal groupings across the five rank values.

Weighting for each metric was calculated based on the number of plans that discussed and assigned value to that metric, either directly or indirectly. For ecological metrics, inclusion in a purely ecological plan was counted twice, while for social metrics, inclusion in a purely social plan was counted twice. These counts were then normalized and converted to weights (out of 100) for calculation of overall ecological and social indices. This approach to weighting captured the relative importance of the various plans ascertained during the plan analysis process, while remaining mechanistic and repeatable. The results of MCDA using a linear additive model were two index values for each study parcel, representing overall potential

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[97] *Ibid.*
[98] *Ibid.*

ecological and social value, with a value between 1 and 5. These results are presented in Section 4.2.

4 Results

4.1 Phase One results

The following section presents the results from the regional plan analysis. Table 4.1-1 lists the plans included in the analysis and summarizes administrative information for each. Below, for each plan, I describe the overall planning or conceptual framework upon which the plan is built, followed by a summary of how the plan defines ecological and/or social value for shoreline habitat restoration within its planning boundaries. I then summarize these results together with some observations about the similarities and differences in the plans' treatment of ecological and social value. Finally, I describe a conceptual model of shoreline habitat restoration in the LDR developed from the regional plan analysis, and present the list of ecological and social metrics derived from this model.

4.1.1 Ecological plan analysis

Table 4.1-2 provides a quick comparison of information about the ecological plans, including restoration goal, species emphasis, restoration terminology, conceptual model, regional prioritization, and site-scale prioritization. This information is provided for each plan in more detail below.

4.1.1.1 NRDA Final EIS for the LDW

This document lays out a framework for the habitat restoration required as part of a Natural Resource Damage Assessment, pursuant to the Superfund designation for the LDW. It was developed by Federal trustees, led by NOAA, in order to determine the extent of injuries to natural resources in the public trust associated with this designation. The plan does not identify or prioritize specific restoration projects; instead, Trustees work with the public to select the

Table 4.1-1: Summary information for regional plan analysis

Plan	Year	Ecological	Social	Regulatory impetus	Planning parties	Planning area	Implementation mechanism
NRDA Final EIS & Restoration Plan for the LDW	2013	x		CERCLA/NRDA	Federal and state Trustee agencies; tribes	LDR: north tip of Harbor Island to North Wind's Weir (7 miles)	NRDA (Trustees or PRPs)
WRIA 9 Salmon Recovery Plan	2005	x		ESA	WRIA9 Forum of Local Governments (15 cities and King County)	Duwamish Estuary subwatershed: north tip of Harbor Island to RM 11	Guidance for WRIA9 grants
City of Seattle Shoreline Master Program	2011	x	x	SMA	City of Seattle	LDR shorezone (200 ft landward of OHWM) within City of Seattle: RM 0.0 to RM 3.5	Restoration: Guidance only; Shoreline use: Municipal Code
City of Tukwila Shoreline Master Program	2009	x	x	SMA	City of Tukwila	LDR shorezone (200 ft landward of OHWM), RM 3.5 to RM 11.0	Restoration: Guidance only; Shoreline use: Municipal Code
King County Shoreline Master Program	2010	x	x	SMA	King County	LDR shorezone (200 ft landward of OHWM), RM 3.5 to RM 5.2, left bank only	Restoration: Guidance only; Shoreline use: Municipal Code
Seattle Parks & Recreation Open Space Plan	2011		x	GMA	City of Seattle	City of Seattle municipal boundaries	Capital Improvements Program
Tukwila Parks, Recreation, and Open Space Plan	2008		x	GMA	City of Tukwila	City of Tukwila municipal boundaries	Capital Improvements Program
SDOT Shoreline Street Ends Program	2009		x	SMA, GMA, City Resolution 29370	City of Seattle	City of Seattle municipal boundaries (street rights-of-way)	SDOT
Seattle Neighborhood Plans (Georgetown, South Park, Delridge, Manufacturing & Industrial Center)	1998-2008		x	GMA	City of Seattle	Neighborhood boundaries within Seattle, as delineated by each plan	Seattle Comprehensive Plan
Duwamish Valley Vision Report	2009		x	CERCLA	Duwamish River Cleanup Coalition	Duwamish Valley (see map)	CERCLA (guidance only)

Table 4.1-2: Summary information for ecological plans

Plan	Restoration goal	Species emphasis	Restoration terminology	Conceptual model	prioritization	prioritization
NRDA Final EIS & Restoration Plan for the LDW	To restore, replace, or acquire the equivalent of those natural resources injured as a result of hazardous substance releases in the LDW	Chinook salmon, English sole, four bird assemblages	Acquisition, Restoration, Rehabilitation, Replacement (Enhancement, Creation)	(Ecosystem processes -->) Key habitats --> Injured natural resources --> Ecological services	On site, in kind: Habitat Focus Areas	HEA for key habitat types + 6 LDR-specific attributes
WRIA 9 Salmon Recovery Plan	Salmon population goals in terms of four "viable salmonid population parameters" (VSPs): abundance, productivity, genetic diversity, and spatial structure	Chinook salmon	Protect, Restore, Rehabilitate, Substitute	(Ecosystem processes -->) Key habitats in the transition zone --> Conservation hypotheses --> VSPs --> ecosystem goods and services	Transition zone (RM 1-10)	8 criteria focused on likelihood of success and magnitude of effect on VSPs; secondary prioritization based on feasibility
City of Seattle Shoreline Master Program	No net loss of shoreline ecological functions	Ecosystem	Protect, Restore, Rehabilitate, Create	Anthropogenic stressors --> ecosystem processes --> create, maintain, or destroy habitat types --> biota affected	Degree of shoreline process impairment (estimated from degree of change from undeveloped condition)	Criteria: land use, level of impairment, opportunity for restoration, ability to address process impairment
City of Tukwila Shoreline Master Program	No net loss of shoreline ecological functions	Ecosystem, with emphasis on Chinook salmon	*No consistent terminology*	Process controls --> ecosystem processes --> key ecosystem functions	Degree of shoreline process impairment + transition zone	Criteria: ability to address habitat functions; inclusion of freshwater tributary channels; cost and feasibility
King County Shoreline Master Program	No net loss of shoreline ecological functions	Ecosystem	Conserve, Preserve, Restore, Enhance, Create	Anthropogenic stressors --> controlling factors ---> ecosystem structures and processes --> ecosystem functions	Degree of shoreline process impairment at *watershed* and *site* scales	Criteria: likelihood of success, feasibility, cost

types of restoration actions defined under this plan, which are then implemented or paid for by the Potentially Responsible Parties (PRPs). As mentioned previously, in the LDW the PRPs include King County, the City of Seattle, the Port of Seattle, the Boeing Company, and numerous other small businesses.

<u>Planning framework</u>

The goal of the NRDA plan is to "restore, replace, or acquire the equivalent of those natural resources injured as the result of hazardous substance releases."[99] For the purpose of the NRDA, these natural resources are defined by representative species assemblages, including Juvenile Chinook salmon and English sole for fish, and four bird assemblages grouped according to foraging behavior: shallow-probing and surface searching shorebirds; waders; surface and diving birds; and aerial searchers. The restoration approach defines key habitats in short supply that are necessary to critical life stages for these key injured species. For the LDR, key habitats include marshes, intertidal mudflats, shallow subtidal flats, and riparian habitat. This approach was based on a combined knowledge of the natural ecological processes of the LDW, more general ecological processes of estuarine environments, the nature and extent of the contamination in the LDW, and current plans for cleanup actions by response agencies.

Acceptable restoration actions include restoration, rehabilitation, replacement (creation, enhancement), and acquisition. The total amount and type of restoration required must match the amount and type of services lost, and is determined using Habitat Equivalency Analysis (HEA). Using the currency unit of a "discounted Service Acre-Year" (dSAY), HEA evaluates the amount and type of restoration required by identifying the environmental components, including habitat types; identifying and quantifying the losses that occurred; identifying the time period

[99] *Ibid,* 3.

over which the losses occurred; calculating total losses; and determining what restoration actions need to be taken to gain back those losses.[100]

Defining value

Broadly defined, the "Trustees prefer restoration projects that enhance ecosystem processes, are integrated into the adjacent natural landscape, and are naturally sustainable."[101] Practically, HEA reveals how the Trustees assign ecological value to restoration projects in the LDR. HEA is widely used for NRDA processes across the country, and is adapted to fit each specific region or ecosystem. For the LDR, the Trustees developed six attributes which, included in a restoration project, would increase the ecological value of that project:

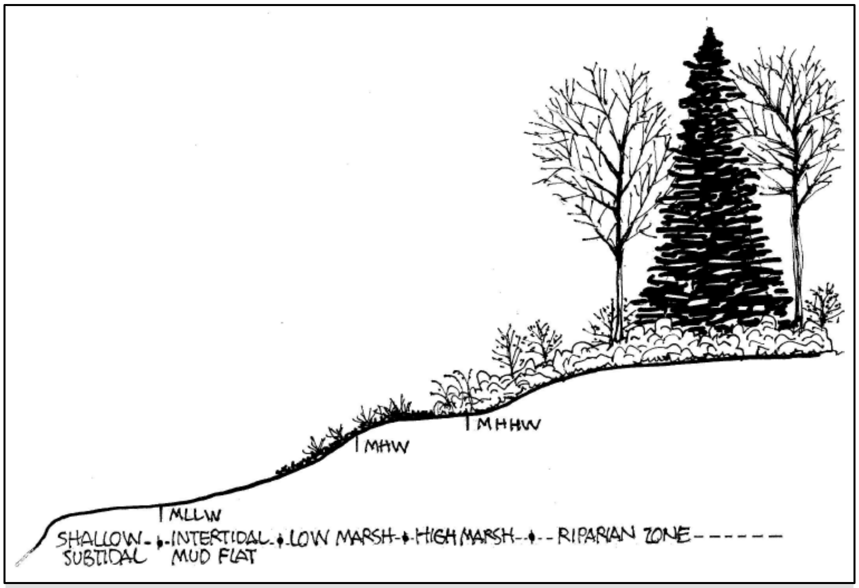

Figure 4-1: The ideal NRDA habitat restoration site features a complete set of contiguous habitat types, including shallow subtidal, intertidal/mudflat, low marsh, high marsh, and riparian zone. Image taken from the NRDA Final PEIS.

- *Overall size.* Bigger is better – larger projects can generally incorporate more types of habitats and be more resilient to stressors.
- *Shape*. This includes site-scale geometry, orientation relative to the river, and other attributes that will vary depending on the type and location of habitat being restored.

[100] *Ibid,* 30.
[101] *Ibid,* 60.

- *Habitat type*. Among the key habitats defined for the LDR, certain habitats are assigned more value within HEA as a product of the relative amount of ecological services they provide to key injured species. For example, estuarine marsh is the most valuable, with intertidal mudflat slightly less valuable.
- *Diversity*. Projects that support a diversity of ecological niches are more valuable. In general, a value "boost" is given to those sites which incorporate all of the key habitats in a contiguous complex (Figure 4-1).
- *Location in the river*. Restoration to replace injured natural resources must be "on site and in kind" – in other words, it must occur where the injury first took place. Projects are given more or less value according to their location within one of four Habitat Focus Areas (HFAs). Top priority is given to projects within HFA1, which includes the lower seven miles of the LDR and encompasses most of the transition zone. Additional value is also given to projects that introduce or restore off-channel or side channel habitat.
- *Landscape connectivity*. Projects located immediately adjacent to existing habitat are assigned more ecological value than those isolated from existing habitat. When this is not possible, projects that introduce habitat into areas that lack it are valuable; in general, habitat restoration located at regular intervals throughout the LDR is a goal.

Overall prioritization of these attributes within HEA gives the most importance to habitat types, followed by location in the river.

4.1.1.2 WRIA 9 Salmon Recovery Plan

In 1999, the Federal listing of Chinook salmon and bull trout as "threatened" under the ESA spurred the Washington State legislature to pass several laws requiring watershed planning. This planning would address issues of habitat degradation in fresh and salt water, identifying priorities and limiting factors. The answer to this call was the development of Watershed Resource Inventory Areas (WRIAs) throughout the state. WRIA 9, which covers the Green-Duwamish and Central Puget Sound watersheds, comprises a forum of local governments including 15 cities and King County. This group, through the WRIA 9 Salmon Recovery Plan, recommends actions that should be taken over the next 10 years to protect and restore salmon habitat. The bulk of the recommendations in this plan will be carried out through a partnership of governments, though individual entities can propose specific restoration projects and apply for WRIA 9 funding.

Planning framework

The goal of the WRIA 9 plan is to "guide protection and restoration of Chinook salmon and bull trout in the Green/Duwamish and Central Puget Sound Watershed."[102] Similar to the NRDA plan, the WRIA 9 plan is based on the underlying premise that there are limiting habitats in the Duwamish Estuary transition zone, and that the quality and quantity of those habitats must be increased in order to recover populations of the target species. The scientific logic underpinning this premise is much more explicit in the WRIA 9 plan, however. The WRIA 9 authors used historical and current habitat conditions, including water quantity and quality; historical and current population conditions; empirical data on fish utilization; and academic knowledge of salmonid ecology to examine the functional linkages between habitat conditions and salmonid populations. These linkages were then described as hypotheses about how improvements in habitat conditions and processes would lead to improvements in key population parameters. These hypotheses were then prioritized for each subwatershed in WRIA 9. In the Duwamish Estuary subwatershed, they focus on vegetated shallow subtidal, intertidal, and marsh

[102] *Ibid,* 2-1.

habitat; enlarging the transition zone; restoring natural sediment processes; increasing side channel, off channel, and tributary access; providing a variety of locations for habitat throughout the river; and addressing water and sediment quality issues.

Habitat management strategies, or restoration actions, should address the processes that support habitat structure or habitat function. Strategies include protection, restoration, rehabilitation, and substitution, and are selected based on the degree of habitat and ecosystem process degradation. This approach is in line with the widely used restoration approach of Roni 2005, Cereghino et al. 2012, and others described in Section 3.2.

Defining value

A WRIA 9 steering committee evaluates projects based on a two-tiered prioritization system. The first prioritization is based on the likelihood of success; the relative magnitude of the project's effect on key population parameters; and the scale of the project. The second prioritization considers factors of political and socioeconomic feasibility, such as risk to private property and financial impacts. Compared to the NRDA HEA model, this system is vague and depends more on site-specific design. However, a few factors considered in the first prioritization define attributes that bring more ecological value to a project:

- *Habitat connectivity*. The WRIA 9 steering committee encourages projects that create or protect corridors that link habitats and reconnect freshwater, estuarine, and saltwater habitats; connect side channels and floodplain areas to the mainstem river channel; or restore fish access where limited by dams, culverts, or other barriers. This last attribute is not applicable within the LDR study area.

- *Location in the river*. Projects within the transition zone, or river miles 1-10, are the focus of this plan.
- *Distribution* of habitat over a variety of locations within the LDR.
- *Presence of ecologically detrimental features*. Shoreline armoring, overwater structures, impervious surface cover, invasive species presence, culverted streams, and combined sewer overflows are all detrimental to habitat value. Projects collocated with such features can generate more ecological value through their removal, and are given priority.

4.1.1.3 Shoreline Master Programs

Shoreline Master Programs (SMPs) are based on three policy goals, as required by the Shoreline Management Act: to establish a preference for water-oriented uses; to protect shoreline natural resources; and to promote public access to shorelines. The plan must balance these three goals for shorelines within its jurisdiction. SMPs are therefore both ecological and social plans for the purpose of this analysis. Restoration planning within an SMP uses a scientific framework, and is included in this analysis as the ecological component of the SMP. The restoration plan is a non-regulatory document, and is dependent on grant funding and a variety of other outside funding sources for implementation. However, "actions to restore and enhance ecological functions, whether as part of mitigation sequencing or otherwise, shall use the Shoreline Restoration and Enhancement Plan as guidance."[103] SMP jurisdictions relevant to the LDR include the City of Seattle,[104] the City of Tukwila,[105] and King County.[106]

[103] City of Seattle, "Shoreline Master Program," 2012, Shoreline Ordinance 23.60A.211B, 183.
[104] City of Seattle, "Shoreline Master Program," 2012.
[105] City of Tukwila, "Shoreline Master Program," 2009.
[106] King County, "King County Comprehensive Plan, Chapter 5: Shorelines," 2012.

Planning framework

Under the SMA, impacts from shoreline development must be offset by habitat restoration in order to ensure "no net loss of shoreline ecological processes."[107] Therefore the goal of the SMP restoration plan is to increase ecological functions by repairing ecological processes or by increasing the amount, size, and/or functions of components of an ecosystem compared to baseline conditions. In order to achieve this goal, SMPs first characterize the shoreline according to relative degree of ecosystem process degradation. This shoreline characterization process follows guidance by Ecology, which is derived from Stanley et al. 2005, and which follows the fundamental logic that ecosystem processes interact with landscape features, climate, and each other to produce the structure and functions of an ecosystem. Anthropogenic stressors affect those processes to create, maintain, or destroy habitat.[108] The shoreline characterization assesses the condition of the shoreline relative to pre-developed conditions, in terms of key ecosystem processes.

Similar to the WRIA 9 approach, SMPs recommend restoration strategies for the LDR based on the relative degree of shoreline process degradation. Protection should be used where habitat is presently functioning at a high level; restoration should be used where habitat is impaired but natural processes can be recovered; and rehabilitation or creation should be used where habitat is impaired or lost and full restoration is not possible. For all three SMPs covered in this analysis, the LDR shoreline was characterized as "most impaired" or "more impaired," with the exception of the Terminal 107 habitat complex. Therefore, the majority of the LDR is a priority region for creation and rehabilitation of habitat, while the Terminal 107 habitat complex is a priority area for protection.

[107] Ecology, "Shoreline Master Program Handbook," 2012, Chapter 4 p. 1.
[108] City of Seattle, "Shoreline Master Program," 2012.

Defining (ecological) value

Both the City of Seattle and City of Tukwila SMPs provide a list of recommended restoration projects within the LDR. In addition to these lists, they describe "no net loss" indicators that can be used to evaluate additional sites for their restoration potential:

- *Presence of ecologically detrimental features*. As in the WRIA 9 prioritization scheme, projects with longer bulkheads, greater impervious surface coverage, larger overwater cover structures, etc. provide greater opportunity to create ecological value through removal of stressors and rehabilitation of habitat.
- *Presence of ecologically valuable features*. Conversely, projects with more mature riparian vegetation, natural wetlands, or freshwater connections provide greater opportunity to maximize ecological value through their restoration or protection.
- *Size*. The previous indicators suggest that potential ecological value is directly related to the size of a project: more linear feet of bulkhead, for example, or more acreage of wetland, translate to more value.

The King County SMP, by nature of its larger geographic coverage, considers watershed-scale ecological processes and functions. At this larger scale, the following factors also determine a project's potential ecological value:

- *Distribution.* Distribution, diversity, and complexity of habitats contribute to overall shoreline ecological function.
- *Connectivity.* Spatial and temporal connectivity within and between watersheds and along marine shorelines also contributes to overall shoreline ecological function.

4.1.2 Social plan analysis

Table 4.1-3 lists social plans and their stated purpose. Information for each plan is provided in more detail below.

Table 4.1-3: Summary information for social plans

Plan	***Stated purpose***
City of Seattle Shoreline Master Program City of Tukwila Shoreline Master Program King County Shoreline Master Program	Promote preferred shoreline uses; protect shoreline natural resources; promote public access to shorelines
Seattle Parks & Recreation Open Space Plan	Provide and maintain parks, open spaces, recreational facilities, and programs to promote respite, socialization, and education
Tukwila Parks, Recreation, and Open Space Plan	Provide cultural and historical value along Tukwila's shoreline
SDOT Shoreline Street Ends Program	Preserve and develop shoreline street ends for public use
Seattle Neighborhood Plans (Georgetown, South Park, Delridge, Manufacturing & Industrial Center)	Address population and economic growth for specific areas within Seattle
Duwamish Valley Vision Report	Articulate a shared community vision for creating a healthy and sustainable Duwamish River Valley

4.1.2.1 Shoreline Master Programs

As mentioned above, SMPs must balance environmental protection with two other policy goals: preferred shoreline uses and public shoreline access. Local governments undertake a community visioning exercise as a required component of the SMP process to ensure that the end product reflects the interests of the community. Any new shoreline development must seek a Shoreline Substantial Development (SSD) permit. Permit reviewers must use the SMP as guidance in permit decisions, including assignment of habitat mitigation or public access components required of the development.

Planning framework

The SMP defines shoreline designations based on a combination of the shoreline characterization process described previously, community input, and economic analysis. These designations are intended to achieve the three-fold purpose of the SMP while minimizing conflict due to incompatible adjacent shoreline uses. The City of Seattle SMP, for example, defines two broad shoreline designations: Urban and Conservancy. Urban shorelines accommodate intense uses such as marine industrial activity, commercial development, or residential development. Conservancy shorelines are intended for low-intensity uses such as public access, recreation, or restoration. Both designations give priority to water-dependent uses.[109] The designations are effectively shoreline zones, and are incorporated into municipal code as part of the zoning ordinance.

<u>Defining (social) value</u>

Shoreline developments, and their associated public access components, must follow certain guidelines and standards in order to obtain approval. Some guidelines are more explicit than others, but taken together these guidelines indicate how SMPs assign social value to shoreline development:

- *Compatibility.* The SMP's emphasis on compatible, water-dependent uses serves both to protect the marine industrial economy and to ensure public safety. In other words, more social value is attributed to any open space or public access area that does not conflict with existing marine industrial activity and that is generally compatible with surrounding land use.
- *Connectivity*. SMPs follow Washington Administrative Code (WAC) standards for regulated public access, including that "the location of the access… shall be chosen to maximize the public nature of the access by locating it adjacent to other public areas

[109] City of Seattle, "Shoreline Master Program," 2012, Shoreline Ordinance, 31-39.

including street-ends, waterways, parks, other public access, and connecting trails."[110] In general, all three SMPs included in this analysis emphasized the importance of a connected network of public areas.

- *Accessibility*. The City of Tukwila and King County SMPs both take connectivity a step further by asserting that public access areas should be accessible to non-motorized traffic through connection to a public right-of-way and/or a pedestrian or bicycle trail.
- *Distribution*. The City of Seattle community envisioned "thriving habitat patches interspersed with thriving marine businesses,"[111] while the King County SMP lists notable geographic absence as a criterion for selecting new public access locations.[112]
- *Proximity*. The King County SMP also defines general population in proximity and/or demand for access at a site as a criterion for public access.[113]
- *Cultural value*. The City of Tukwila SMP prioritizes public access on sites with cultural value, including historical features, public art, unique natural features such as historic river meanders, early Native American sites, or archaeological sites. These areas have the potential to provide more than one form of public access, and therefore provide increased social value.[114]

4.1.2.2 SDOT Shoreline Street Ends Program

Public streets that end on waterfronts provide an opportunity for public access to a shoreline that may otherwise be dominated by private property. In Seattle alone, 149 public streets end on waterfronts. In 1996 the City of Seattle adopted City Resolution 29370,

[110] *Ibid,* 106.
[111] City of Seattle, "Shoreline Master Program," 2012, Citizen Advisory Committee Report and Appendix.
[112] King County, "King County Comprehensive Plan, Chapter 5: Shorelines," 2012.
[113] *Ibid.*
[114] City of Tukwila, "Shoreline Master Program," 2009.

designating public access as the highest and best use of shoreline street ends. Since then, the Seattle Department of Transportation (SDOT) has worked to improve these sites for public access and enjoyment. Street ends selected for improvement undergo a formal public process to ensure the improvement action reflects the interests of the community. Though the scope of the Street Ends Program is narrower than other plans included in this analysis, it works in concert with the Seattle SMP and Comprehensive Plan. Furthermore, its narrow focus allows clarity relative to the other plans in terms of what attributes bring social value to a potential public access site.

Planning framework

Specific goals of the Street Ends Program include helping to create vibrant, livable urban neighborhoods; improving public access to and enjoyment of Seattle's shoreline; enhancing shoreline habitat; encouraging community stewardship of shoreline street ends; supporting maritime industry; and deterring non-permitted encroachments on shoreline property.

Defining value

The Street Ends Program developed criteria for evaluating and prioritizing shoreline street ends for improvement. These directly translate into attributes that bring social value to potential shoreline developments:

- *Proximity.* Sites should be close to high-density neighborhoods or urban villages.
- *Accessibility.* Sites should be close to existing or planned bicycle routes or trails.
- *Distribution.* Sites should reduce any gaps in public shoreline access.

- *Compatibility.* Sites should be compatible with surrounding land uses, topography, circulation patterns, and adjacent open space and/or pedestrian activity patterns to provide safe public use. In areas with a predominant pattern of industrial water-dependent uses, shoreline street end improvements should be designed and located to minimize conflicts and operational impacts on adjacent businesses.
- *Community support.* In addition to including public involvement, sites should be compatible with other City-adopted policies and plans.

4.1.2.3 Parks and Open Space Plans

Planning for open space is required under both the City of Seattle and City of Tukwila Comprehensive Plans, and is also required for grant eligibility from the Washington State Recreation and Conservation Office.[115] The planning process must include formal public involvement in order to ensure that resulting plans reflect community interests. Park plans are then implemented by municipal Capital Improvement Programs.

Planning framework

The overall goals for both plans are to benefit the community through an adequate balance of parks, open spaces, recreational facilities, and programs that serve each city's population. Open space provides a wide range of services in each city. It can take many forms, each of which provides a particular subset of those services, from respite and interaction with nature to socialization and education. The City of Seattle distinguishes "breathing room open space" from "usable open space" in its plan and sets different citywide goals for the amount of each. Breathing room open space is defined as the combined acreage of all dedicated open

[115] City of Seattle, "Seattle's Parks and Recreation 2011 Development Plan," 2011, 2.

spaces, whereas usable open space should be relatively level and open in order to be suitable for more active recreation.[116] In addition to simple distribution goals, Tukwila's plan aims to provide cultural and historical value along the City's shoreline.[117]

Beyond determining citywide goals, open space plans provide the framework for long-term stewardship of parks and open spaces, including maintenance of existing facilities and acquisition of properties to fill gaps in open space as the city grows. New open spaces are the result of environmental inventories, field analysis, workshop planning sessions, and surveys of residents. Siting considerations include existing supply, demonstrated demand, and feasibility concerns such as cost and constructability. Like their SMPs, the Seattle and Tukwila open space plans also emphasize the importance of compatibility with surrounding land uses. The open space plans both also include significant discussion of preserving sensitive habitat for threatened species and urban wildlife. Tukwila's plan asserts the contribution of wildlife habitat to the overall cultural and historical value of the city's shoreline.[118] Though the purpose of each plan is to provide social benefit through open space, this emphasis indicates the inherent social value of habitat.

Defining value

Both plans propose specific sites for new parks, preserves, or other dedicated open spaces. Given that the plans were developed with community input, locating a restoration project at one of these sites would ensure community support. In addition to naming specific sites, both plans lay out standards and guidelines for siting and design of new parks not included in the plan. These guidelines help such parks maximize benefit to the community:

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[116] *Ibid.*
[117] City of Tukwila, "Parks, Recreation, and Open Space Plan," 2008.
[118] *Ibid*, A-3.

- *Open space distribution.* Both plans assert the importance of a regular distribution of open space. Seattle defines this as ¼ to ½ acre within ¼ to ½ miles of every resident;[119] Tukwila defines specific acreage goals per 1,000 residents for each type of open space.[120]
- *Public access distribution.* In addition to setting distribution standards for open space, the City of Seattle also aims to provide at least one public shoreline access point for every half mile of shoreline.[121]
- *Proximity to population.* Facilities should be "within a convenient and serviceable proximity to using populations;"[122] usable open space in particular should be located in such a way that it's easily accessible and intended to serve the immediate urban village.[123] The Seattle plan anticipates increased demand for close-to-home recreation due to a struggling economy and increasing urbanism, particularly for Seattle's less affluent population.[124]
- *Connectivity.* New parks and open spaces should link existing open spaces and greenways. Both plans stress the importance of open space networks, which visually define and separate developing urban areas from each other in accordance with the objectives of the GMA.[125] Tukwila specifically calls out the need to increase natural area linkages along the Duwamish/Green River Trail corridor.[126]
- *Accessibility*, including connection to public right-of-ways or other public property, is particularly important for usable open space as defined in the Seattle plan.[127]

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[119] City of Seattle, "Seattle's Parks and Recreation 2011 Development Plan," 2011, 3.
[120] City of Tukwila, "Parks, Recreation, and Open Space Plan," 2008, D-1.
[121] Maggie Glowacki, e-mail message to author, 2012.
[122] City of Tukwila, "Parks, Recreation, and Open Space Plan," 2008, 66.
[123] City of Seattle, "Seattle's Parks and Recreation 2011 Development Plan," 2011, 2.
[124] *Ibid,* 42.
[125] City of Tukwila, "Parks, Recreation, and Open Space Plan," 2008, 21.
[126] *Ibid,* 6.
[127] City of Seattle, "Seattle's Parks and Recreation 2011 Development Plan," 2011.

- *Cultural value.* A valuable open space system includes lands that can provide unique habitats, cultural, features, or historical associations. Both plans identify and incorporate significant historical and cultural lands, sites, and artifacts into the open space system to "provide a balanced social experience."[128]

4.1.2.4 Seattle Neighborhood Plans

In 1995 Seattle implemented a neighborhood planning process as a core component of its Comprehensive Plan. The process was intended to address population and economic growth for the city as a whole as well as for specific areas within the city. Residents, businesses, and property-owners in each of Seattle's 38 neighborhoods developed blueprints for how their neighborhoods would grow toward a better future.[129] The plans, which are updated regularly, are incorporated into Seattle's Comprehensive Plan or otherwise addressed by appropriate City departments as possible. The neighborhood plans of Georgetown, South Park, Delridge, and the Manufacturing and Industrial Center (MIC) cover neighborhoods within the Duwamish Valley and are included in this analysis.

<u>Planning framework</u>

Each plan lays out the goals each neighborhood has for its future, defining guidelines for future development and growth. These guidelines express the unique identity of each neighborhood, and the values that go along with it. Georgetown is a neighborhood defined by the unique juxtaposition of an affordable urban residential community adjacent to active heavy industry.[130] Georgetown's plan expresses a desire to preserve and enhance its unique character,

[128] City of Tukwila, "Parks, Recreation, and Open Space Plan," 2008, 7.
[129] City of Seattle, "Neighborhood Planning," 2014.
[130] Georgetown Planning Committee, "Georgetown Neighborhood Plan," 1999.

including the presence of a thriving design community, the abundance of historic buildings, and the Duwamish River. South Park is more residential than Georgetown, and less spatially and culturally integrated with the industrial core nearby. South Park's neighborhood plan goals focus more on the quality of life of its residents, including preserving residential lands and increasing community amenities.[131] Delridge is even more residential, and is a self-named "place where community and natural environment are integrated."[132] The neighborhood is more physically separated from the industrial activity, and features the large riparian corridor of Longfellow Creek that runs through the neighborhood, as well as concentrated nodes of commercial activity distributed along its north-south axis. Finally, the MIC neighborhood plan focuses almost entirely on economic development, and on the preservation of Seattle's industrial lands upon which it relies. Similar to Seattle's Comprehensive Plan, all four neighborhood plans use elements to frame long-term goals and guidelines. Elements common to most plans include community identity/historic preservation, open space/recreation, economic development, and environment.

All four plans focus on the unique identity of the neighborhood in question, striving to preserve and capitalize on this identity. The LDR is called out as an important component of this identity for Georgetown, South Park, and the MIC, while Delridge's focus is more broadly on environmental stewardship. All four plans assert the importance of preserving industrial lands for the economic vitality of the city, and more specifically giving waterfront priority to water-dependent marine industry. At the same time, all four neighborhoods stress the need for buffers between industrial and non-industrial land uses, and the general danger of incompatible uses. The plans recognize the potential for green space to serve this buffer purpose, and assert the

[131] South Park Planning Committee, "South Park Residential Urban Village Plan," 1998.
[132] Delridge Planning Committee, "Delridge Neighborhood Plan," 1999.

general need for increased open space. This open space may serve different purposes depending on the nature of the neighborhood. For example, the Delridge plan's discussion of open space is more focused on conservation of environmental features, while for Georgetown it is more about buffering from industrial uses, and in South Park about providing usable open space as a community amenity. However, all three plans state the need for a well-connected, well-integrated network of open space to provide a diverse range of services both ecological and social.

Defining value

In addition to the values described above, each of the plans includes lists or maps of proposed amenities, including parks, preserves, community centers, or historical features to preserve. These mapped features imply support for the development of community amenities in those locations. Taken together, the text and maps from each plan indicate important values with respect to environmental features, including habitat restoration:

- *Proximity.* In addition to neighborhood boundaries, clusters of existing and proposed facilities indicate neighborhood nuclei. Locating restoration sites near such clusters increases social value because residents and visitors to the neighborhood are more likely to visit such sites. Proximity to industry is also valuable if the location of a restoration site or open space serves as a buffer between industrial and non-industrial land uses.
- *Distribution of open space and public access.* As mentioned, the majority of the plans stressed the importance of more open space and more access to the river.
- *Connectivity.* As mentioned, open space that is well connected, forming an integrated open space network, is more valuable than isolated patches.

- *Accessibility.* In addition to being located near people, open spaces should be located such that barriers to access, including industrial activity or arterial roadways, are minimized. The South Park plan in particular encourages would-be park developers to "look to right-of-ways" to ensure public access.[133]
- *Cultural value.* Open spaces that incorporate and preserve features of cultural value help the Duwamish Valley neighborhoods achieve their overall goals of preserving cultural identity.

4.1.2.5 Duwamish Valley Vision Report

The Duwamish River Cleanup Coalition (DRCC) serves as the EPA's Community Advisory Group for the Lower Duwamish Waterway Superfund and associated NRDA settlements. In this role the DRCC ensures that the cleanup and restoration plans developed by the Trustees are informed by and align with the community most affected by them. For the LDR Superfund this includes residents, businesses, and property-owners within the Duwamish Valley, including the residential communities of South Park, Georgetown, SODO, Delridge/Youngstown, Highland Park, and High Point; as well as industrial businesses, recreational users, and tribal and subsistence fishermen. To develop the Duwamish Valley Vision Report, the DRCC undertook a community visioning process involving eight workshops held in four languages, interviews, and electronic surveys.

[133] South Park Planning Committee, "South Park Residential Urban Village Plan," 1998.

Planning framework

The goal of the Duwamish Valley Vision Report is to "articulate a shared community vision for creating a healthy and sustainable Duwamish River Valley."[134] The report provides a comprehensive framework for planning a sustainable future for the Duwamish River Valley, addressing four main elements: environment, community amenities, economic development, and transportation. Each of these elements was developed entirely from community input, including a map-based exercise in which participants proposed locations for desired amenities or features of the Duwamish Valley landscape. The environment element includes goals related to air quality, water quality, habitat and restoration, and parks and recreational amenities. The focus of the community amenities element is on community connectedness and civic engagement, as well as preserving community character. The community defined goals and identified desired features related to affordable housing, recreation/entertainment, and arts/cinema. The economic development element focuses on maintaining a healthy mix of industrial and residential land within the Valley, acknowledging the importance of active industry to the local economy. Finally, the transportation element focuses on public and non-motorized transportation, asserting a need for connectivity between neighborhoods, between public access sites along the river, and between parks and the river.

Defining value

As with the neighborhood plans, mapped features developed by the community and included in the Duwamish Valley Vision Report imply support for the development of community amenities in those locations. The maps also indicate values for open space and restoration. For example, siting of a future habitat area next to an established park might indicate

[134] *Ibid,* 25.

the importance of connectivity to the open space network, or to existing community gathering places. Taken together, the text and maps from the visioning process indicate important values with respect to environmental features, including habitat restoration:

- *Distribution of open space and public access.* The visioning process resulted in universal agreement about the need for more parks, open space, trails, and public shoreline access areas. Public access is particularly scarce on the east side of the river, where industrial lands occupy most of the available area outside of the Georgetown neighborhood core. The report suggests a "string-of-pearls" approach to habitat and open space development at street ends and other small pockets along the river, particularly in areas without active industrial activities that may present safety hazards to visitors.
- *Proximity.* Following on the safety concerns mentioned above, green spaces can provide a buffer from industrial activities for shoreline visitors in residential areas. In general, open spaces, access points, and habitat should be located to facilitate access by nearby residents, visitors, and workers, and to enhance other neighborhood features such as retail corridors or community attractions.
- *Cultural value.* "Vision participants point to the Duwamish River as a unique opportunity for people to experience salmon and other wildlife, marine traffic, industry, and vibrant neighborhoods all in one place."[135] Open spaces along the river that incorporate this concept, either through existing or created cultural features, increase social value.

[135] *Ibid*, 65.

4.1.3 Summary and observations

4.1.3.1 Ecological plan comparison

The ecological plans included in this analysis are all grounded in very similar scientific conceptual models, supported by the regional restoration literature, including Stanley et al. 2005, Roni et al. 2005, and Cereghino et al. 2012. Though specific terminology varies from plan to plan, all of them rely on the logic that ecosystem processes, which shape habitat structure and function, are degraded by anthropogenic stressors. This degradation reduces not only habitat structure and function, but also the ecosystem services produced by the habitat and valued by humans. Plans generally agree that fundamental ecosystem processes have been altered and are irretrievable, and that true restoration is therefore not an appropriate goal. Depending on the level of degradation, restoration strategies address ecosystem process, structure, or function, restoring them to some past or ideal state in an effort to produce ecosystem services. The translation of this logic model into restoration planning and prioritization, however, results in significant differences between plans. At the subwatershed and reach scale, the SMPs prioritize restoration strategies based entirely on degree of degradation. The WRIA 9 plan adds salmon population ecology to this approach, combining habitat degradation metrics with hypotheses about the effects of that degradation on valued salmon population parameters. Both plans provide site-scale prioritization schemes as well, but these focus almost exclusively on considerations of feasibility. By contrast, the NRDA plan prioritizes restoration at the subwatershed scale based on the historical location of natural resource injury. Site-scale prioritization is then based on a specific set of metrics, giving value only to the particular types of habitat identified as critical to those natural resources.

These differences may be explained by the administrative framework behind each plan. Both the WRIA 9 plan and SMPs are broader in scope and in geographic scale than the NRDA plan. Though it contains a separate planning effort for the Duwamish Estuary subwatershed, WRIA 9 covers the entire Central Puget Sound. The SMPs for Seattle, Tukwila, and King County, must plan for all shorelines within their jurisdiction. The NRDA plan, by contrast, was developed specifically to address habitat restoration in the LDR. Perhaps more importantly, the NRDA plan holds authority over parties required under federal law to perform habitat restoration. The WRIA 9 plan and SMPs, though required under state law, serve more as guidance documents for permitting and funding decisions. The implication of this difference – between the "carrot" and the "stick" – is that the NRDA plan can afford to be much more *prescriptive* in prioritizing restoration, while the WRIA 9 plan and SMPs must avoid being *restrictive*. The implication is that the NRDA plan is more purely based on science, and should for the purpose of this research contribute more to the definition of ecological value in the LDR than the other plans, which necessarily dilute scientific considerations with practical ones.

4.1.3.2 Social plan comparison

The social plans included in this analysis generally agree that the social value of a restoration site, open space, or other green development stems from people interacting with it. Site selection and site design of any such development should therefore strive to maximize interaction. Strategies for doing so vary somewhat from plan to plan, and in general, there is more diversity of content among the social plans than among the ecological ones. While the ecological plans rely on science as a foundation, content for each social plan comes directly from the community, resulting in much more variability. Rather than pull from a regional body of accepted scientific knowledge, each social plan develops a framework to match its particular purpose. This is evident in looking at the SMPs included in this analysis. The restoration plans for each SMP have similar conceptual models and similarly formatted results, based off of the shoreline characterization guidelines provided by Ecology. Treatment of the other two policy goals, however – provision of public access and designation of preferred shoreline uses – varies greatly among the three SMPs. While King County develops a rigorous method to identify gaps in shoreline public access, Seattle simply sets a city-wide distribution goal, and Tukwila describes spatially vague public access standards.

The two open space plans are also very different from each other. At the city scale, Tukwila relies on national standards for open space and recreation, while Seattle defines its own population-based distribution standards. However, at the site scale, both plans define explicit methods for prioritizing open space projects. The SDOT plan also defines an explicit method for prioritizing shoreline public access projects. These plans are similar in that they all actively propose real projects for short- and long-term implementation as part of their overall purpose. The SMPs, the Seattle neighborhood plans, and the Duwamish Valley Plan, by contrast, are long-range planning documents that provide guidance rather than site-specific proposals. Any prioritization methods defined by these latter plans are therefore vaguer and less actionable, and metrics for social value in the LDR must be inferred.

4.1.3.3 Overall comparison

In general, ecological plans tend to define value more explicitly than social plans, using analytical models or prioritization schemes where social plans use nonhierarchical "wish lists." This may be a product of the differences between science and community planning, or may instead be a reflection of the different authorities guiding the planning process for each set of plans. Regardless, to account for this relative ambiguity, more characteristics are needed to define social value than ecological value.

Though both ecological and social plans define characteristics that vary in space throughout the LDR, social plans are much more focused on spatial context. This reflects the emphasis on interaction described above: the degree to which people interact with a restoration site or green space is directly dependent on the immediate surroundings of that site. Surroundings can contribute to interaction if they are characterized by vibrant pedestrian activity, community amenities, and a sense of safety. Conversely, surroundings can act as a physical or psychological barrier to interaction if they are characterized by high-speed roads, industrial activity, or unsafe environments, for example. Social plans acknowledge the detrimental effects on social value of incompatible uses. Ecological plans, on the other hand, largely ignore land uses outside of the potential habitat network, except to address their role in habitat degradation.

All plans both ecological and social address the challenges of creating green space in an urban environment. In addition to simple space constraints, planning in the LDR requires a never-ending struggle for balance between oft-conflicting objectives: quality of life, quality of environment, and economy. This is reflected in the SMPs' three-pronged policy goals of public access, ecological function, and water-dependent uses. Certain features that make a restoration site more socially valuable, such as proximity to a large population, may make it less ecologically successful. Similarly, restoration in the most heavily degraded areas, such as industrial centers, may limit social value due to public safety concerns. Despite the ubiquity of these trade-offs, however, none of the plans address the implications of human interaction with nature in an urban environment. These trade-offs are more clearly revealed through phase two of this research, and are discussed in more detail in Section Five.

4.1.4 Conceptual model

Planning for habitat restoration in the LDR is a process that spans several spatial scales, from the entire estuary subwatershed down to individual slivers of waterfront property. At each scale, different variables contribute to ecological or social value, and therefore become important for planners to consider. Accordingly, the conceptual models developed for habitat restoration in the LDR organize the planning process into three scales of decreasing spatial scope: system, network, and site. At each scale, different characteristics of habitat restoration contribute to ecological or social value. Figures 4-2 and 4-3 show, respectively, the conceptual models for ecological value and social value of habitat restoration in the LDR.

In the ecological model, the system is defined as the entire LDR subwatershed. At this scale, restoration priority is assigned based on the level of alteration of natural ecosystem processes within a given stretch of the river. Generally, the more degraded these processes, the more in need the area is of habitat restoration, rehabilitation, enhancement, or creation. Ecosystem function within a given stretch can inform which of these restoration strategies will be most successful. The network scale represents the collection of habitat sites throughout the LDR,

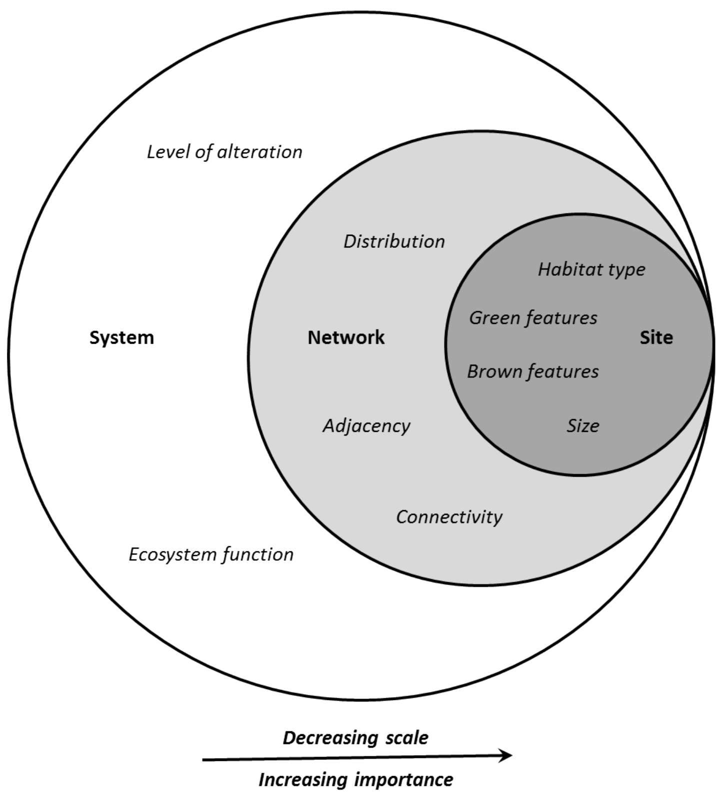

Figure 4-2: Conceptual model of the ecological value of habitat restoration in the LDR.

including shoreline and upland habitat. A regularly distributed, highly connected habitat network provides more ecological value than a fragmented collection of habitat patches. New restoration should connect patches to each other, or reconnect altered hydrological features, such as creeks and wetlands, to the river. Finally, the site represents the scale of a single restoration project, which for the purpose of this research is defined as a parcel of waterfront property in the LDR. At this scale, planners must consider restoration design features that maximize the amount of ecological lift that can be generated from the site. Lift may be calculated using Habitat Equivalency Analysis or some other method, but generally depends on the size of the parcel, the types of habitat created, incorporation of ecologically valuable features such as off-channel areas or wetlands, and removal of stressors such as armoring or overwater cover. As ecological lift is at the core of habitat valuation for the organizations performing habitat restoration in the LDR, the site scale is the most important of the three spatial scales in the conceptual model.

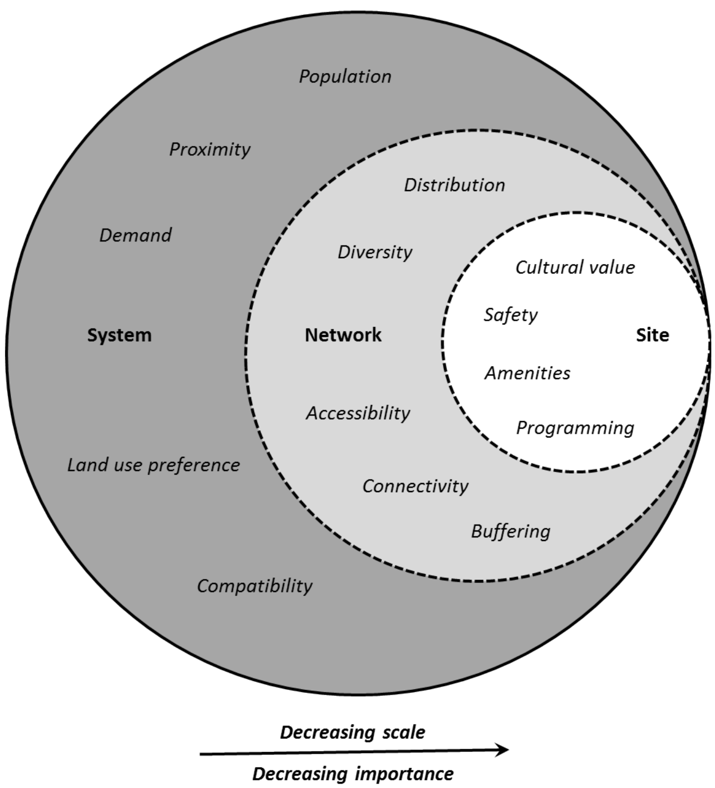

Figure 4-3: Conceptual model of the social value of habitat restoration in the LDR.

In the social model, the system is defined as the entire Lower Duwamish River Valley, which is home or workplace to the stakeholders who benefit from restoration in the LDR. At this scale, planners consider spatial context, including the compatibility of adjacent land uses and preservation of preferred land uses such as industrial and residential. Planners use zoning to ensure that every use is in its proper place in order to minimize negative impacts. At the same time, contextual considerations such as proximity to neighborhood centers, serviceable population, and demonstrated demand also contribute to social value by increasing the likelihood of interaction. The social plans included in the analysis emphasize the importance of spatial context; therefore this scale is the most important of the three in the model. The network scale represents the collection of open space, including habitat sites, throughout the LDR. As with ecological value, a regularly distributed, highly connected open space network provides more social value. Open spaces within the network should minimize barriers to access and provide a diversity of recreation opportunities. The network as a whole should provide definition, or buffering, between natural areas and urban land uses. In the conceptual model diagram, the line between the system and network scales is dashed to indicate that, in order to serve a buffering function, open space networks must be planned with an understanding of system-scale spatial context. Finally, at the site scale, social value can be increased through incorporation of culturally or historically unique features; educational or community programming; amenities such as playgrounds, restrooms, or playfields; and public safety. In the conceptual model diagram, the line between the network and site scales is dashed to indicate that design features such as landscaping and amenities can contribute to a diverse, balanced network of recreation opportunities.

Site selection for habitat restoration within the LDR requires decision-making at all three scales, with decreasing flexibility and decision-making as the scale gets smaller. Site scale design decisions made after site selection can also influence the ecological or social value of a restoration project. Based on these conceptual models, these site scale decisions are more important, or contribute more, to ecological value than system scale decisions. Social value, with its emphasis on spatial context, relies more on site selection. This partially justifies the opportunistic approach to site selection taken by organizations pursuing ecological value only, as described in Section Two. However, long-term monitoring and protection of a restoration site in perpetuity must be considered at all scales in order to ensure ecological value in the long-term.[136] Opportunism fails to address this long-term consideration, as does the conceptual model for ecological value. By considering elements of the social value conceptual model, restoration planners could more effectively incorporate spatial context as well as community support. These are critical elements of any land use decision, and would help ensure the long-term ecological and social success of habitat restoration projects in the LDR.

Using the conceptual models presented above, I developed a list of metrics for potential ecological and social value of restoration in the LDR. I then culled this list using the criteria discussed in Section 3.2.3.3. The final set of ecological and social metrics is shown in Table 4.1-4 below.

Table 4.1-4: Final list of ecological and social metrics

Ecological	***Social***
Scientific priority	Community priority
Adjacency	Serviceable population
Habitat distribution	Proximity
Size	Cultural value
Green features	Accessibility
Brown features	Open space distribution
	Public access distribution
	Connectivity

4.2 Phase Two results

Results are summarized for all ecological and social metrics below, then presented for individual metrics. For each metric, I describe how it was operationalized and calculated, then

136 Cereghino et al., "Strategies," 2012.

summarize numerical and spatial results. Maps of all metrics are presented together at the end of this section. Results for all metrics for all parcels are included at the end of this document as Appendix C. Methodology models for each metric are included as Appendix A, and a complete data dictionary is included as Appendix B.

4.2.1 Ecological metrics

4.2.1.1 Summary results for ecological metrics

Results for all ecological metrics are presented in the three tables below. Table 4.2-1 shows summary statistics for the values calculated for each metric. These values were then used to determine rank value ranges, which are shown in Table 4.2-2. The rank value ranges formed the ecological basis of the linear additive model described in Section 4.2.3. Parcels were then assigned rank values according to their raw metric values. The distribution of parcels by rank value for each metric is shown in Table 4.2-3.

Table 4.2-1: Summary statistics for ecological metrics

Metric	*Definition*	*Measurement Type*	*Minimum*	*Maximum*	*Mean*	*Standard Deviation*
Scientific Priority	Degree of scientific support	Rank	0	3	0.6	0.9
Adjacency	Adjacent to or containing existing shoreline habitat	Binary	0	1	0.2	0.4
Habitat Distribution	Area-weighted distance from existing habitat network (ft)	Continuous	0	8211	1760	1696
Size	Total area of shorezone + submerged land (acres)	Continuous	0.0	47.7	1.5	3.6
Green Features	Number of ecologically beneficial features	Rank	0	3	0.2	0.1
Brown Features	Number of ecologically detrimental features	Rank	0	4	1.2	1.2

Table 4.2-2: Ecological value criteria matrix

Metric	Definition	Measurement Type	Best: 5	4	3	2	Worst: 1
Scientific Priority	Designated (by an ecological plan) as a priority area for restoration	Rank	3: site + stretch	2: site		1: stretch	0
Adjacency	Adjacent to or containing existing shoreline habitat	Binary	1				0
Habitat Distribution	Introduces habitat to an area that lacks it: Area-weighted distance from existing habitat network (ft.)	Continuous	4663-8212	2750-4662	1630-2749	629-1629	0-628
Size	Total area of shorezone + submerged land (acres)	Continuous	18.7-47.7	9.1-18.6	3.8-9.0	1.3-3.7	0.0-1.2
Green Features	Number of ecologically beneficial features, including stream mouth; off-channel area; disconnected wetland; riparian stream buffer	Rank	4	3	2	1	0
Brown Features	Number of ecologically detrimental features, including armored shoreline; overwater cover; impervious surfaces; CSO outfall	Rank	4	3	2	1	0

Table 4.2-3: Parcel counts for ecological metrics (511 parcels total)

Metric	Definition	Measurement Type	Best: 5 (Number of parcels / Percent total parcels)	4	3	2	Worst: 1
Scientific Priority	Designated (by an ecological plan) as a priority area for restoration	Rank	**23** 4	**62** 12		**91** 18	**335** 66
Adjacency	Adjacent to or containing existing shoreline habitat	Binary	**102** 20				**409** 80
Habitat Distribution	Introduces habitat to an area that lacks it: Area-weighted distance from existing habitat network (ft.)	Continuous	**36** 7	**85** 16	**106** 21	**112** 22	**172** 34
Size	Total area of shorezone + submerged land (sq.ft.)	Continuous	**3** 1	**16** 3	**36** 7	**83** 16	**373** 73
Green Features	Number of ecologically beneficial features, including stream mouth; off-channel area; disconnected wetland; riparian buffer	Rank	**0** 0	**3** 1	**12** 2	**46** 9	**450** 88
Brown Features	Number of ecologically detrimental features, including armored shoreline; overwater cover; impervious surfaces; CSO outfall	Rank	**10** 2	**82** 16	**96** 19	**138** 27	**185** 36

4.2.1.2 Individual metric methodologies

Scientific priority

Definition: Designation by an ecological plan of the parcel, or the area immediately waterward of the parcel, as the proposed location of or a higher priority area for restoration.

Input data types: Polygons of proposed restoration sites; digitized priority restoration areas.

Encoding:

3: Parcel is both selected as the proposed location of a restoration project (site), and is located in a higher priority stretch of the river (stretch)

2: Parcel is selected as the proposed location of a restoration project (site)

1: Parcel is located in a higher priority stretch of the river (stretch)

0: None of the above

Proposed restoration projects and high priority stretches of the river were digitized from the ecological plans listed in Table 3.2-1. Shoreline designations from Shoreline Master Programs, as described in the previous section, were not included in this metric. Taken together, these plans designated the entire LDR as highly degraded and a high priority for restoration or recovery.[137] This does not contribute to the process of differentiating parcels within the LDR for the sake of site selection. Instead, it reflects the dire need for restoration in the entire LDR, which is the underlying motivation for this thesis project. Stretch-scale "projects" identified in the WRIA 9 Salmon Recovery Plan were also excluded. Instead of prioritization, these projects identify overall restoration acreage goals by stretch for the entire WRIA 9 Lower Duwamish Subwatershed.[138] Therefore the only higher priority stretch included is Habitat Focus Area One (HFA1) from the NDRA Final EIS, which is based on a scientific assessment of the nature of the natural resource injury in the LDR, and which is a strong determinant of habitat value for those

[137] City of Seattle, "Shoreline Master Program," 2012; City of Tukwila, "Shoreline Master Program," 2009; King County, "King County Comprehensive Plan, Chapter 5: Shorelines," 2012.
[138] WRIA 9 Steering Committee, "Salmon Habitat Plan" 2005.

organizations restoring under NRDA liability.[139] Parcels within HFA1 and also containing identified site-level restoration projects were given the highest value under this metric, with decreasing value assigned based on decreasing site specificity.

Twenty-three parcels were selected for both site- and stretch-scale priority, and were assigned the highest rank value. Sixty-two were selected at the site-scale only, and 91 at the stretch scale. This left 335 parcels, or 66 percent, that were not identified as priority by any ecological plan. The mean value for this metric was 0.6, with a standard deviation of 0.9. Looking at the spatial distribution of scientific priority (see Map E1), HFA1 noticeably increases the overall value of the downstream seven miles of the LDR in terms of this metric. The most desirable sites are clustered around the Terminal 107/Terminal 108 hub just south of the southern tip of Harbor Island, as well as farther south near the planned restoration projects at Terminal 117 and Boeing Plant Two.

<u>Adjacency</u>

Definition: Adjacency to or on-site presence of existing restoration sites.

Input data types: Polygons of existing restoration sites.

Encoding:

1: Parcel intersects one or more existing restoration site polygons

0: Parcel does not intersect one or more existing restoration site polygons

According to the NRDA Final EIS, restoration sites that build off of existing habitat are more valuable than those that stand alone.[140] This added value does not apply to restoration sites

[139] NOAA, "Final LDR NRDA Restoration Plan and Programmatic EIS," 2013.
[140] *Ibid,* 66.

constructed across the river from existing habitat.[141] Existing restoration sites were digitized from ecological plans to form a network of existing habitat on either side of the LDR. Parcels were then assigned a binary value for adjacency: those that intersect or are adjacent to this network were designated as adjacent; all others were designated as not adjacent.

One hundred and two parcels were designated as adjacent to existing habitat, and were assigned the highest rank value. This left 409 parcels, or 80 percent, that were not adjacent to existing habitat. The mean value for this metric was 0.2, with a standard deviation of 0.4. Looking at the spatial distribution of adjacency (see Map E2), the vast majority of adjacent parcels are located within the downstream seven miles of the river, as this area has been a focus of restoration efforts in the LDR. Notable restoration hubs include the Terminal 105/Terminal 107/Terminal 108 complex south of Harbor Island, and the upstream extent of the Commercial Waterway around Turning Basin 3.

Habitat distribution

Definition: Degree to which parcel introduces habitat in an area that lacks it.

Input data types: Polygons of existing restoration sites.

Encoding: Area-weighted distance from existing restoration sites (ft.)

Existing restoration sites were digitized from ecological plans to form a network of existing habitat. I then applied ArcMap's Euclidean Distance tool to this network. The output of this operation was a raster of 10 foot-by-10 foot pixels, each containing a value for the Euclidean distance to the nearest habitat. These values were then extracted and averaged for each parcel, effectively giving an area-weighted distance from that parcel to the habitat network as a whole. Parcels with higher area-weighted distance values (more distant habitat) were interpreted as more

[141] Jon Sloan, personal communication with author, May 6, 2014.

ecologically valuable and assigned higher rank values than those with lower area-weighted distance values (closer habitat).

Values for habitat distribution are continuous, so ranks were determined based on natural breaks. Thirty-six parcels received the highest rank value, with an area-weighted distance of 4663 to 8212 feet. Relative to the previous two metrics, values for habitat distribution were distributed more evenly, with 34 percent receiving the lowest rank value (0-628 feet). The mean value for this metric was 1760 feet, or one-third of a mile, with a standard deviation of 1696 feet. Looking at the spatial distribution of this metric (see Map E3), higher ranked stretches of the river include the river mouth at the northern end of Harbor Island; the stretch between the Terminal 107 habitat hub and the First Avenue Bridge; and the southernmost extent of the study area in Tukwila. This reflects an effective inverse of the results seen for the adjacency metric, and is indicative of a fundamental trade-off in all restoration decisions which will be discussed more in Section Five.

<u>Size</u>

Definition: Total area of shore zone and submerged land within parcel.

Input data types: Polygon of 200-foot-wide shoreline buffer (shore zone).

Encoding: For each parcel: Area of shore zone + area of submerged land within parcel boundaries

As defined in the NRDA Final EIS as well as the Seattle SMP, larger restoration sites are more valuable than small ones.[142] However, parcel size is not necessarily an appropriate proxy for the size of a potential restoration site, which may be constrained by existing land uses.

[142] NOAA, "Final LDR NRDA Restoration Plan and Programmatic EIS," 2013; City of Seattle, "Shoreline Master Program," 2012.

However, as discussed previously, under the SMA these land uses must obtain permits for any work done within the shore zone. These permits require mitigation, in the form of compensatory restoration, for any harm the permitted development causes to ecological functions within the shore zone.[143] Therefore, the total area of shore zone, as well as the submerged land waterward of the shore zone, is a more appropriate proxy for the size of potential restoration associated with this parcel. To calculate this area, I used ArcGIS's Union tool to clip the portion of the shore zone and submerged land polygons within each parcel, then dissolved those polygons and calculated the sum of their area. Larger total areas were assigned higher rank values according to natural breaks in the range of sizes for all parcels.

Values for size are continuous, so ranks were determined based on natural breaks. Only three parcels received the highest rank value, with a total shore zone area of 18.7 to 47.7 acres. The overwhelming majority of parcels had much smaller shore zone areas, with 73 percent receiving the lowest rank (0.0-1.2 acres). The mean value for this metric was 1.5 acres, with a standard deviation of 3.6 acres. Looking at the spatial distribution of this metric (see Map E4), parcels within the marine industrial core tend to be larger than residential parcels in Seattle and Tukwila. A few exceptions include large parcels owned by the Boeing Company near Turning Basin Three, and the large publicly-owned Foster Golf Course in Tukwila near the southern end of the study area.

<u>Green features</u>

Definition: Number of ecologically beneficial features within parcel boundaries, including: stream mouth; off-channel area; wetland; riparian buffer.

[143] Washington Administrative Code (WAC) 173-27: Shoreline Management Permit and Enforcement Procedures (2011).

Input data types: Stream polylines; critical areas polygons; off-channel designation (manual).

Encoding: Total number of green features that fall within parcel boundaries

The locations of ecologically beneficial features, including stream mouths, off-channel areas, wetlands, and riparian buffers, were digitized as points and polygons. For the polygon features (wetlands and riparian buffers), size of the feature, or amount of overlap with the parcel, was not considered. Instead, the total number of all features within each parcel boundary was summed, with higher numbers receiving higher rank values for this metric.

Four types of green features were digitized and counted, but no single parcel within the LDR contained all four. Three parcels contained three green features, and 46 contained one, but the overwhelming majority of parcels (88 percent) contained zero green features. The mean value for this metric was 0.2, with a standard deviation of 0.1. Looking at the spatial distribution of green features (see Map E5), green features are relatively evenly distributed throughout the study area. However, a significant stretch of the river between Terminal 107 and just north of Turning Basin Three lack streams, and as a result have lower average rankings for this metric than elsewhere on the river.

<u>Brown features</u>

Definition: Number of ecologically detrimental features within parcel boundaries, including: armored shoreline (>50%); overwater cover structures; impervious surfaces (>50%); and CSO outfalls.

Input data types: Shoreline armoring polylines; polygons of overwater cover structures; CSO points; raster satellite imagery

Encoding: Total number of brown features that fall within parcel boundaries

To calculate this metric, point and vector data were distilled down to a collection of four ecologically detrimental features: armored shoreline, overwater cover structures, impervious surfaces, and CSO outfalls. CSO outfalls were digitized as points from maps provided online by King County.[144] The presence of overwater cover structures was assessed using a combination of overwater cover structure polygons from the PSNERP Change Analysis database[145] and visual identification using Google Earth aerial imagery.[146] The presence of armored shoreline was defined by coverage of 50 percent or more of a parcel's shoreline with armoring of any kind. This was assessed using a combination of armoring polyline data from the PSNERP Change Analysis database and visual classification using Google Earth aerial imagery. Finally, the presence of impervious surfaces was defined by coverage of 50 percent or more of a parcel's surface area with any impervious surface. This was assessed using a combination of impervious surface polygon data from the PSNERP Change Analysis database and visual identification using Google Earth aerial imagery. The total number of ecologically detrimental features within each parcel boundary was summed, with higher numbers receiving higher rank values for this metric.

As with green features, four types of brown features were digitized and counted. However, brown features were much more evenly distributed throughout the study parcels. Ten parcels, or two percent, contained all four, and 185, or 36 percent, contained zero. Thus the majority of the parcels, or 62 percent, contained one, two, or three brown features. The mean value for this metric was 1.2, with a standard deviation of 1.2. Looking at the spatial distribution of green features (see Map E6), there is a noticeable decrease in brown features as you move south, or upstream, along the river. Given the high-intensity nature of the development associated with the marine industrial uses in the northern seven miles of the river, this is to be

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144 King County, "King County Combined Sewer Overflow (CSO) Locations," 2013.
145 Simenstad et al., "Historical Change and Impairment of Puget Sound Shorelines," 2011.
146 Google Earth, "Lower Duwamish River," 2014.

expected. Indeed, the lowest-scoring parcels within the marine industrial area, including Terminals 105, 107, and 108, are those that feature completed habitat restoration projects that removed their previous brown features. Overall, residential neighborhoods, particularly those in Tukwila, feature much less urban development and are therefore less likely to use armored shorelines, overwater structures, or impervious ground cover.

4.2.2 Social metrics

4.2.2.1 Summary results for social metrics

Results for all social metrics are presented in the three tables below. Table 4.2-4 shows summary statistics for the values calculated for each metric. These values were then used to determine rank value ranges, which are shown in Table 4.2-5. The rank value ranges formed the social basis of the linear additive model described in Section 4.2.3. Parcels were then assigned rank values according to their raw metric values. The distribution of parcels by rank value for each metric is shown in Table 4.2-6.

Table 4.2-4: Summary statistics for social metrics

Metric	*Definition*	*Measurement Type*	*Minimum*	*Maximum*	*Mean*	*Standard Deviation*
Community Priority	Degree of community support	Rank	0	7	1.3	2.0
Serviceable Population	Number of residents within half-mile buffer	Continuous	0	4001	936	814
Proximity	Area of overlap of half-mile buffer with neighborhood centers (acres)	Continuous	0	334	89	71
Cultural Value	Number of culturally-significant features	Rank	0	5	0.6	0.8
Accessibility	Adjacent to non-arterial public right-of-way and/or bike trail	Binary	0	1	0.7	0.4
Open Space Distribution	Area-weighted distance from existing open space network (ft)	Continuous	0	3034	569	583
Public Access Distribution	Distance along the shoreline to nearest public access point (ft)	Continuous	0	8695	992	1553
Connectivity	Connected to open space network, including habitat	Binary	0	1	0.3	0.5

Table 4.2-5: Social value criteria matrix

Metric	*Definition*	*Measurement Type*	*Best: 5*	*4*	*3*	*2*	*Worst: 1*
Community Priority	Designated (by a community plan) as a priority area for restoration, open space, or public access	Rank	7	5-6	3-4	1-2	0
Serviceable Population	Number of residents within a half-mile buffer	Continuous	2266-4002	1513-2265	870-1512	374-869	0-373
Proximity	Near to proposed or existing community amenities and neighborhood centers: Area of overlap of half-mile buffer with neighborhood centers (acres)	Continuous	183-334	122-182	71-121	28-70	0-27
Cultural Value	Number of culturally-significant features on the site	Rank	5-6	3-4	2	1	0
Accessibility	Accessible for pedestrians and bicyclists: Adjacent to non-arterial public right-of-way and/or bike trail	Binary	1				0
Open Space Distribution	Introduces open space to an area that lacks it: Area-weighted distance from existing open space network (ft.)	Continuous	1620-3034	872-1619	477-871	187-477	0-186
Public Access Distribution	Introduces public shoreline access along a stretch that lacks it: Distance along the shoreline to nearest public access point (ft.)	Continuous	4701-8695	2692-4700	1393-2691	459-1392	0-458
Connectivity	Connected to open space network, including habitat	Binary	1				0

Table 4.2-6: Parcel counts for social metrics (511 parcels total)

					Number of parcels *Percent total parcels*		
Metric	*Definition*	*Measurement Type*	*Best: 5*	*4*	*3*	*2*	*Worst: 1*
Community Priority	Designated (by a community plan) as a priority area for restoration, open space, or public access	Rank	**10** 2	**17** 3	**123** 24	**23** 5	**338** 66
Serviceable Population	Number of residents within a half-mile buffer	Continuous	**44** 9	**67** 13	**128** 25	**95** 19	**177** 35
Proximity	Near to proposed or existing community amenities and neighborhood centers: Area of overlap of half-mile buffer with neighborhood centers (acres)	Continuous	**59** 12	**128** 25	**74** 14	**115** 23	**135** 26
Cultural Value	Number of culturally-significant features on the site	Rank	**1** 0	**10** 2	**66** 13	**156** 31	**278** 54
Accessibility	Accessible for pedestrians and bicyclists: Adjacent to non-arterial public right-of-way and/or bike trail	Binary	**379** 74				**132** 26
Open Space Distribution	Introduces open space to an area that lacks it: Area-weighted distance from existing open space network (ft.)	Continuous	**37** 7	**76** 15	**115** 23	**141** 28	**142** 28
Public Access Distribution	Introduces public shoreline access along a stretch that lacks it: Distance along the shoreline to nearest public access point (ft.)	Continuous	**17** 3	**43** 8	**56** 11	**124** 24	**271** 53
Connectivity	Connected to open space network, including habitat	Binary	**153** 30				**358** 70

4.2.2.2 Individual metric methodologies

Community priority

Definition: Designation by a social plan as a priority area for restoration, open space, or public access.

Input data types: Points and polygons of proposed restoration sites, open spaces, and public access sites.

Encoding:

- 7: Parcel designated as restoration or breathing room open space AND public access AND usable open space; OR parcel designated as an industrial buffer
- 6: Parcel designated as restoration or breathing room open space AND public access
- 5: Parcel designated as restoration or breathing room open space AND usable open space
- 4: Parcel designated as restoration or breathing room open space
- 3: Parcel designated as public access AND usable open space
- 2: Parcel designated as public access
- 1: Parcel designated as usable open space
- 0: None of the above

Proposed open space polygons and public access points were digitized from social plans to form a network of proposed open space and public access. In digitizing, I preserved information about the type of open space proposed, forming three categories: usable open space, breathing room open space, restoration, and public access. These categories were derived from the Seattle Parks & Recreation Open Space Plan, which sets separate city-wide goals for breathing room open space and usable open space. The different functions of these two types of open space have different implications for restoration. The more passive recreational uses associated with breathing room open space, such as walking or viewing nature, are more compatible with restoration. Furthermore, a restoration site itself is a kind of breathing room open space. Access points are also associated with more passive recreational uses, and can easily be incorporated into restoration site design.[147] By contrast, a restored wetland, for example, may preclude the kinds of active recreational uses intended for usable open space.[148] Finally, several plans identified the importance of open space of any kind serving as a buffer between industrial and residential uses. In order to capture these varied proposals and values, I developed a ranking system for this metric based on the degree to which the community's proposal(s) would be satisfied were a restoration site to be constructed on a given parcel. Parcels with proposals very conducive to, or in support of, restoration, were given higher rank values than those with less support.

Similar to the scientific priority metric for ecological value, 66 percent of parcels were given the lowest rank value for community priority, meaning they were not identified as the proposed location for restoration, open space, or public access. Twenty-four percent of parcels received a raw metric value of three or four; the remaining raw metric values were evenly distributed throughout the remaining parcels. The mean value for this metric was 1.3, with a standard deviation of 2.0. Looking at the spatial distribution of community priority (see Map S1), the majority of community-identified locations is in the marine industrial portion of the LDR, with hot spots around the neighborhoods of South Park and Georgetown. This result may reflect a sample bias in the regional plan analysis: while the included plans cover all neighborhoods in the LDR, those within Seattle were effectively represented twice as a result of the visioning process that generated the Duwamish Valley Vision Report. Alternatively, it could reflect the

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[147] Seaport Planning Group, "Portfolio of Habitat Initiative Projects," 2014.
[148] NOAA, "Final LDR NRDA Restoration Plan and Programmatic EIS," 2013.

perception that the LDR is more highly functioning in the southern, less developed portion of the river, and therefore less in need of restoration. As shown on Map E1, this perception is not supported by the even distribution of habitat projects proposed by scientifically-developed plans.

<u>Serviceable population</u>

Definition: Number of residents within a half-mile buffer of the parcel.

Input data types: Census block polygons; census population tables by census block for King County.

Encoding: For each parcel: $\sum_{\text{all census blocks}}$([Individuals per square foot]$_{\text{census block}}$*[Area (sq. ft.) of overlap with half-mile parcel buffer])

In the field of planning, one half mile is widely used as the limit for walkability.[149] Accordingly, the Seattle Parks & Recreation Open Space Plan defines a standard of usable open space within 0.25-0.5 miles of every resident.[150] Therefore in order to calculate serviceable population, half-mile buffers were calculated for each parcel. Total population by census block, together with census block area, was used to calculate population density for each census block.[151] For each parcel, the area of overlap of a census block with that parcel's half-mile buffer was multiplied by the block's calculated population density to estimate the number of individuals from that block living within the half-mile buffer. These estimates were then summed for all overlapping census blocks to give a total serviceable population for that parcel.

Values for serviceable population are continuous, so ranks were determined based on natural breaks. Forty-four parcels received the highest rank value, with an estimated 2266 to 4002 residents within a half-mile buffer. Three hundred ninety-five parcels, or 77 percent, were

[149] Moudon et al., "Operational Definitions of Walkable Neighborhoods," 2005.
[150] City of Seattle, "Shoreline Street Ends," 2009, 3.
[151] U.S. Census Bureau, "Population by Census Block for All Blocks, King County, WA," 2014.

assigned the lowest two rank values, with an estimated zero to 869 residents within a half-mile buffer. The mean value for this metric was 936 residents, with a standard deviation of 1553 residents. Looking at the spatial distribution of this metric (see Map S2), hot spots are unsurprisingly located near neighborhoods such as Downtown Seattle, South Park, and higher density residential areas in Tukwila and unincorporated King County. Parcel area also seems to play a role in these results, with larger parcels casting larger half-mile buffers from their perimeter, and therefore encircling relatively more residents than a similarly-located but smaller parcel might.

Proximity

Definition: Nearness to proposed or existing community amenities and neighborhood centers.

Input data types: Polygons of existing neighborhood centers; polygons of proposed neighborhood centers; points of existing community amenities; points of proposed community amenities.

Encoding: For each parcel: $\sum_{\text{all neighborhood centers}}$(Area (acres) of overlap with half-mile parcel buffer)

Neighborhood boundaries, urban village boundaries, and retail corridors were digitized from Seattle neighborhood plans. For neighborhood centers outside of Seattle, zoning maps were used to isolate high-density residential and retail centers. The locations of community amenities, including schools, libraries, community centers, arts centers, and human service centers were digitized as points. Through mapping both neighborhood centers and community amenities, it became clear that community amenities were largely clustered within neighborhood center boundaries. Thus neighborhood centers alone were used to calculate this metric, with the assumption that each center contains a denser collection of community amenities relative to areas outside that center. Total area of overlap for each parcel was calculated using the same methodology as used for serviceable population, described above.

Values for proximity are continuous, so ranks were determined based on natural breaks. Compared to serviceable population, proximity values are somewhat more evenly distributed. Fifty-nine parcels received the highest rank value, with 183 to 334 acres of neighborhood centers within a half-mile buffer. Two hundred fifty parcels, or 49 percent, were assigned the lowest two rank values, with an estimated zero to 70 acres of neighborhood centers within a half-mile buffer. The mean value for this metric was 89 acres, with a standard deviation of 71 acres. The spatial distribution of this metric (see Map S3) is similar to that of serviceable population, with more pronounced hot spots in Tukwila and Georgetown. The increased social value for this metric near Georgetown reflect a neighborhood planning area that incorporates significant industrial and artistic studio space beyond its small residential areas. This illustrates an important distinction between the two metrics, with proximity capturing social value for those non-residents who work in or visit these neighborhood centers.

<u>Cultural value</u>

Definition: Number of proposed and existing culturally significant features on the parcel.

Input data types: Points and polygons of proposed and existing culturally-significant features.

Encoding: Total number of points and polygons that fall within or overlap, respectively, parcel boundaries

The locations of culturally significant features, including Native American heritage areas, historically significant buildings, museums, and the relic LDR channel, were digitized as points.

The total number of these points within each parcel boundary was calculated as an indicator of the potential or existing cultural value within that parcel.

Two hundred thirty-three parcels, or 46 percent, contained at least one culturally significant feature. The mean value for this metric was 0.6, with a standard deviation of 0.8. Looking at the spatial distribution of cultural value (see Map S4), cultural features are concentrated in the southern half of the study area. Many of the parcels containing the largest numbers of these features are currently public parks, such as the Foster Golf Course, Cecil Moses Memorial Park, and Fort Dent Park. This might indicate a flaw in the metric's logic if these cultural features were created because of the parks. However, the majority of the cultural features are sites with historical significance, indicating that the reverse is more likely: parks were located in these locations because of their historical significance. Therefore a restoration project located on a parcel that scored highly on this metric is likely to have more social value than one on a parcel that did not score as high.

<u>Accessibility</u>

Definition: Ease of access for pedestrians and bicyclists.

Input data types: Road rights-of-way (polygon); street arterial designations (polyline); trails (polyline).

Encoding:

- 1: Parcel is adjacent to (intersects) existing non-arterial public right-of-way or trail
- 0: Parcel is not adjacent to (does not intersect) existing non-arterial public right-of-way or trail

According to the DRCC, major arterials prevent public access for long stretches along the LDR.[152] The City of Seattle, in its Shoreline Master Program, asserts that open spaces and public access points have the most value if they are adjacent to other public areas, including street ends.[153] In terms of spatial analysis, parcels not cut off from the LDR by arterial roads, and those connected to some non-arterial mode of transportation, are more accessible. I calculated accessibility by extracting non-arterial public road right-of-way polygons around the LDR. I then merged these with the trail network to create a pedestrian- and bicycle-friendly transportation network. Parcels were then assigned a binary value for accessibility: those that intersect or are adjacent to this network were designated as accessible; all others were designated as inaccessible.

Three hundred seventy-eight parcels, or 74 percent, were designated as accessible, and were assigned the highest rank value. This left 132 parcels designated as inaccessible. The mean value for this metric was 0.7, with a standard deviation of 0.4. Looking at the spatial distribution of accessibility (see Map S5), inaccessible parcels are present in a few consolidated stretches along the river, including around Harbor Island, and south of Georgetown throughout Boeing property on the east side of the river. In both of these cases, the parcels are cut off from access by an arterial road that separates the parcel from surrounding non-riverfront parcels. The Duwamish/Green River trail, which is managed by King County, runs along the western shore of the LDR for almost the entire study area, providing more access to this half of the river relative to the eastern shore.

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[152] DRCC, "Duwamish Valley Vision Map & Report," 2009.
[153] City of Seattle, "Shoreline Master Program," 2012.

Open space distribution

Definition: Degree to which parcel introduces open space in an area that lacks it.

Input data types: Polygons of existing open spaces, including restoration sites.

Encoding: Area-weighted distance from existing open spaces (ft.)

Existing parks, preserves, restoration sites, and other designated open spaces were digitized from social plans to form a network of existing open space. Values for this metric were then calculated using the same methodology as described for habitat distribution in the previous section. Parcels with higher area-weighted distance values (more distant open space) were interpreted as more socially valuable and assigned higher rank values than those with lower area-weighted distance values (closer open space).

Values for open space distribution are continuous, so ranks were determined based on natural breaks. Thirty-seven parcels received the highest rank value, with an area-weighted distance of 1620 to 3034 feet. One hundred forty-two parcels, or 28 percent, received the lowest rank value, with an area-weighted distance of zero to 186 feet, with the remaining 332 parcels distributed across the other three rank values. The mean value for this metric was 569 feet, with a standard deviation of 583 feet. Note that these values are significantly lower overall than analogous values from the habitat distribution metric. This indicates that open space is much more densely distributed and available in the LDR than habitat. Looking at the spatial distribution of this metric (see Map S6), hot spots are present at the northern edge of the study area around Harbor Island, south of Terminal 108 on the east bank, and throughout Boeing property on the east bank. These areas are all within the marine industrial core.

Public access distribution

Definition: Degree to which parcel introduced public shoreline access in an area that lacks it.

Input data types: Points of existing shoreline public access.

Encoding: Distance (ft.) along water-facing parcel edge to nearest public access point

The City of Seattle defines its city-wide goal for public shoreline as at least one access point per half mile.[154] However, for most of the LDR, this goal has been met. In other words, the vast majority of LDR parcels are less than one half mile from the nearest public access point. In order to develop a public access distribution metric that would more precisely and meaningfully distinguish parcels, I calculated the networked distance to the nearest public access point for each parcel. Existing public access points along the LDR were digitized from social plans to form a network of shoreline public access. For ease of calculation I defined the network as a continuous line along the water-facing edge of the LDR parcels on either side of the river. I then used ArcGIS's Near tool to calculate the distance from that water-facing edge (polyline) to the nearest public access point for each parcel. Parcels with higher distances to the nearest public access point were interpreted as more socially valuable and assigned higher rank values than those with lower distance values.

Values for public access distribution are continuous, so ranks were determined based on natural breaks. Seventeen parcels received the highest rank value, with a distance of 4701 to 8695 feet to the nearest public access point. Two hundred seventy-one parcels, or 53 percent, received the lowest rank value with a distance between zero and 458 feet. The mean value for this metric was 992 feet, with a standard deviation of 1553 feet. Compared to both habitat and open space distribution, these numbers indicate that public access points are distributed throughout the LDR in a similar density to habitat; however, more parcels are farther from these

[154] Maggie Glowacki, e-mail message to author, 2012.

access points. Looking at the spatial distribution for this metric (see Map S7) confirms that this is due to a concentration of public access points along the northern stretch of the river, as well as a general clustering of all points rather than an evenly-spaced distribution. Also, the east bank has significantly fewer access points (20) than the west bank (30).

Connectivity

Definition: Adjacency to existing open space.

Input data types: Polygons of existing open spaces, including restoration sites.

Encoding:

1: Parcel is adjacent to (intersects) existing open space or restoration site

0: Parcel is not adjacent to (does not intersect) existing open space or restoration site

Existing parks, preserves, restoration sites, and other designated open spaces were digitized from social plans to form a network of existing open space. Parcels were then assigned a binary value for connectivity: those that intersect or are adjacent to this network were designated as connected; all others were designated as not connected.

One hundred fifty-three parcels were designated as connected to the existing open space network, and were assigned the highest rank value. This left 358 parcels, or 70 percent, that were not connected to existing open space. The mean value for this metric was 0.3, with a standard deviation of 0.5. Looking at the spatial distribution of connectivity (see Map S8) reveals slightly more connected parcels on the west bank than the east. Overall the map shows an even distribution of connected and disconnected parcels, indicating a similarly even distribution of open space.

4.2.3 Application of linear additive model

Taken individually, the metric results presented in the previous two sections provide spatial information about specific variables. Each brings to light different trends and phenomena regarding restoration and ecological and social value in the LDR, and each could provide the foundation for its own in-depth analysis. However, in order to look more broadly at the spatial distribution of ecological and social value in the LDR, I used a linear additive model to combine these variables in a meaningful way with minimal loss of information. The results of this process are presented below.

4.2.3.1 Weighting

Weights for each metric were determined based on the number of plans that identified them as contributing ecological or social value to restoration projects in the LDR (see Section 3.2.4.4). Tables 4.2-7 and 4.2-8 show weights developed for ecological and social metrics, respectively.

Table 4.2-7: Weighting methodology and results for ecological metrics

	Ecological metrics					
Plan	*Scientific priority*	*Adjacency*	*Habitat distribution*	*Size*	*Green features*	*Brown features*
NRDA Final EIS & Restoration Plan for the LDW	x	x	x	x	x	
WRIA 9 Salmon Recovery Plan	x	x	x		x	x
City of Seattle Shoreline Master Program	x			x	x	x
City of Tukwila Shoreline Master Program	x	x			x	x
King County Shoreline Master Program		x	x		x	x
Total	4	4	3	2	5	4
Weighted total*	6	6	5	3	7	5
Weight for decision matrix	**20**	**20**	**15**	**5**	**25**	**15**

*Purely ecological plans are weighted twice as heavily (count as two plans, effectively) compared to hybrid plans (i.e. SMPs)

Table 4.2-8: Weighting methodology and results for social metrics

	Social metrics							
Plan	*Community priority*	*Serviceable population*	*Proximity*	*Cultural value*	*Accessibility*	*Open space distribution*	*Public access distribution*	*Connectivity*
City of Seattle Shoreline Master Program	x		x		x		x	x
City of Tukwila Shoreline Master Program	x		x	x	x		x	
King County Shoreline Master Program	x	x	x	x	x		x	
Seattle Parks & Recreation Open Space Plan	x	x			x	x	x	
Tukwila Parks, Recreation, and Open Space Plan	x	x	x	x		x	x	x
SDOT Shoreline Street Ends Program	x	x	x		x		x	
Seattle Neighborhood Plans	x		x	x	x	x	x	x
Duwamish Valley Vision Report	x		x	x		x	x	
Total	8	4	7	5	6	4	8	3
Weighted total*	13	7	11	8	9	8	13	5
Weight for decision matrix	**20**	**10**	**15**	**10**	**10**	**10**	**20**	**5**

*Purely ecological plans are weighted twice as heavily (count as two plans, effectively) compared to hybrid plans (i.e. SMPs)

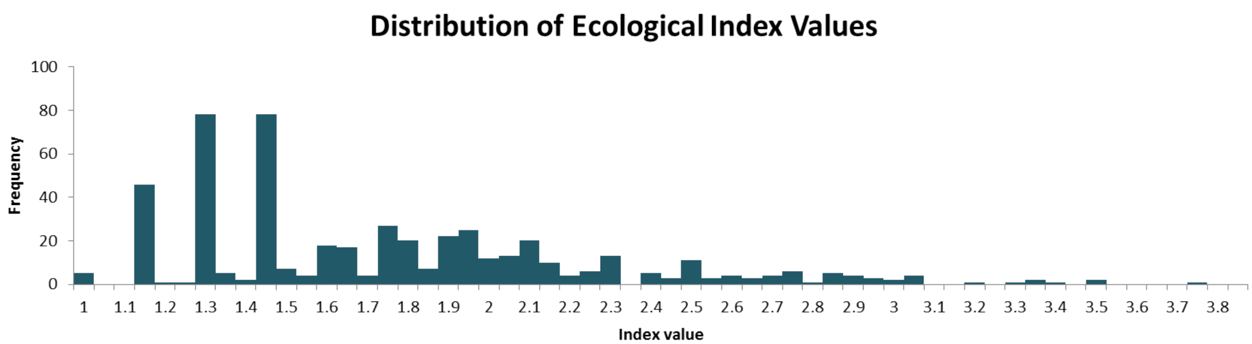
4.2.3.2 Index values

Using the results from the previous two sections, I calculated ecological and social index values for each parcel according to the following method:

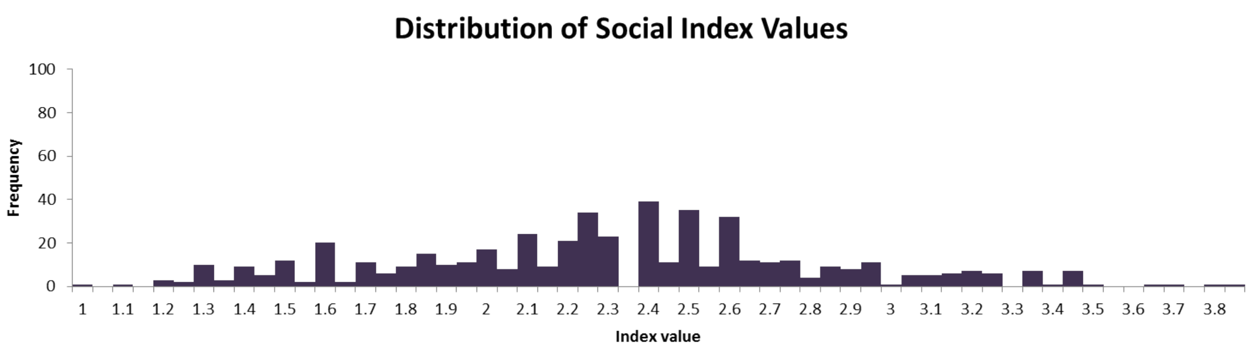
$$Index = [\sum_{all\ metrics} (metric\ value * weight)]/100$$

This yielded an ecological and social index value between one and five for each parcel. These values are presented at the end of this document as Appendix C. The distributions of ecological and social index values are shown together with summary statistics for each in Figure 4-4 below. Due to the nature of the linear additive model used, a one-to-one comparison of numeric values between ecological and social indices is not appropriate. Criteria and their rankings were derived empirically from within each population of values, and were not normalized across metrics or between indices. Therefore, in reporting and analyzing these data, I focus instead on comparison of population distributions and spatial trends.

In general, social index values were more widely distributed, with a maximum frequency of occurrence of any one index value of 39, compared to 78 for the ecological index. The distribution curve for ecological index is also much more skewed to the left, reflecting a population with generally more low values than the social index population. These results indicate that, within the population of study parcels in the LDR, a greater number of parcels have higher potential social value than have higher potential ecological value.



Average index value: 1.76	Maximum index value: 3.7	Average frequency: 8.8
Standard deviation of index value: 0.50	Maximum frequency: 78	Standard deviation of frequency: 15.6



Average index value: 2.28	Maximum index value: 3.8	Average frequency: 8.8
Standard deviation of index value: 0.51	Maximum frequency: 39	Standard deviation of frequency: 9.3

Figure 4-4: Histograms showing the distribution of values for both ecological and social indices.

Looking at the spatial distribution of both indices (see Map I1) reveals similar overall patterns of high and low potential value for both indices, with a more monochrome map for social index illustrating its relatively even distribution. Ecological index is overall higher in the northern, industrial stretch of the LDR, with values tapering off noticeably south of Turning

Basin Three. By contrast, social index values are on average slightly higher in this southern section. Figure 4-5 plots index value with latitude in order to illustrate this overall north-south trend. Social index values are generally higher as the river passes through neighborhoods such as South Park, Georgetown, and the residential areas of Tukwila and unincorporated King County. Ecological index values seem most tied to the existing habitat network, which plays a role either directly or indirectly in several metrics.

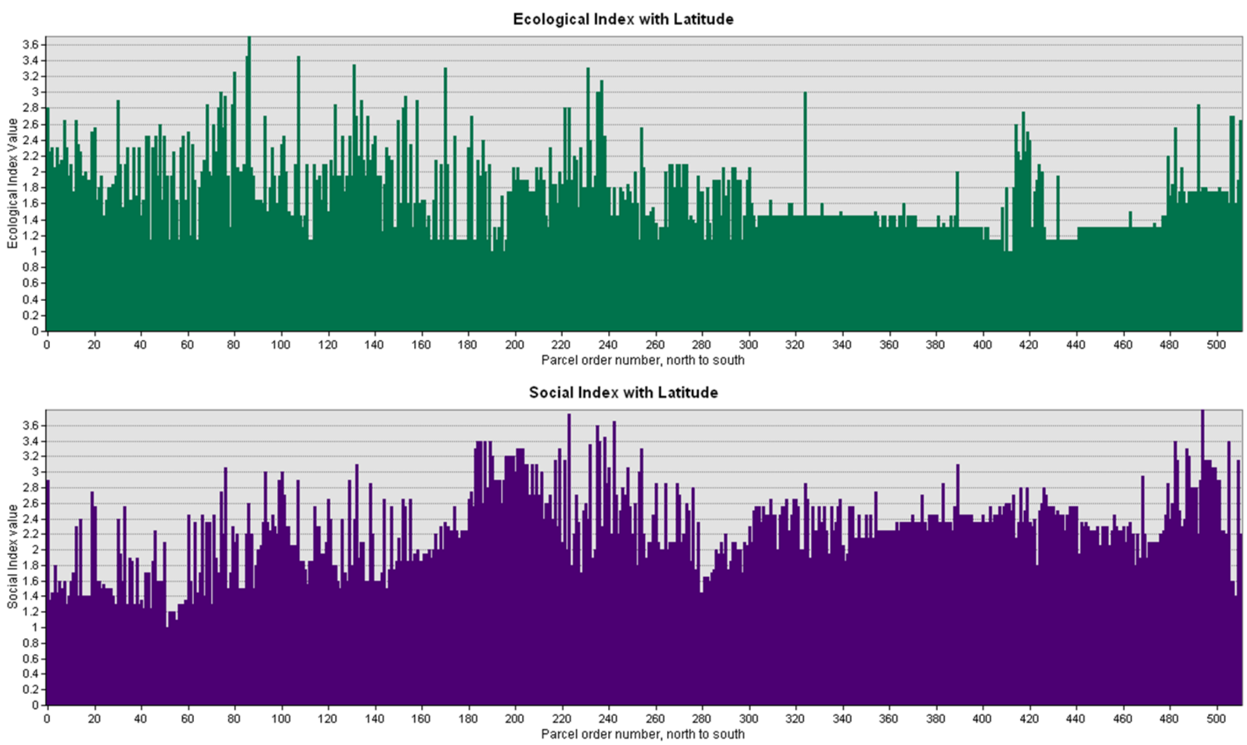


Figure 4-5: Ecological and social index values with latitude (left to right = north to south).

I tested the apparent north-south difference in index values for both ecological and social value using a simple independent-samples t-test. "South" parcels were defined as those with centroids upstream of Turning Basin Three, which marks the end of the federal navigable channel and the southern boundary of the Manufacturing and Industrial Center.[155] "North" parcels were those with centroids downstream of, and including, the Turning Basin. This

[155] Greater Duwamish Planning Committee, "Greater Duwamish Manufacturing and Industrial Center Plan," 1999.

definition resulted in 244 north parcels and 267 south parcels. For the ecological index, there was a significant difference between index values for north parcels (mean = 1.99, standard deviation = 0.53) and south parcels (mean = 1.54, standard deviation = 0.35); $t(416) = 11.31$, $p < 0.0001$, alpha = 0.05. For the social index, the t-test showed no significant difference between index values for north parcels (mean = 2.18, standard deviation = 0.62) and south parcels (mean = 2.37, standard deviation = 0.35); $t(379) = -4.23$, $p < 0.0001$, alpha = 0.05. These results suggest that ecological index values are higher in the industrialized portion of the river.

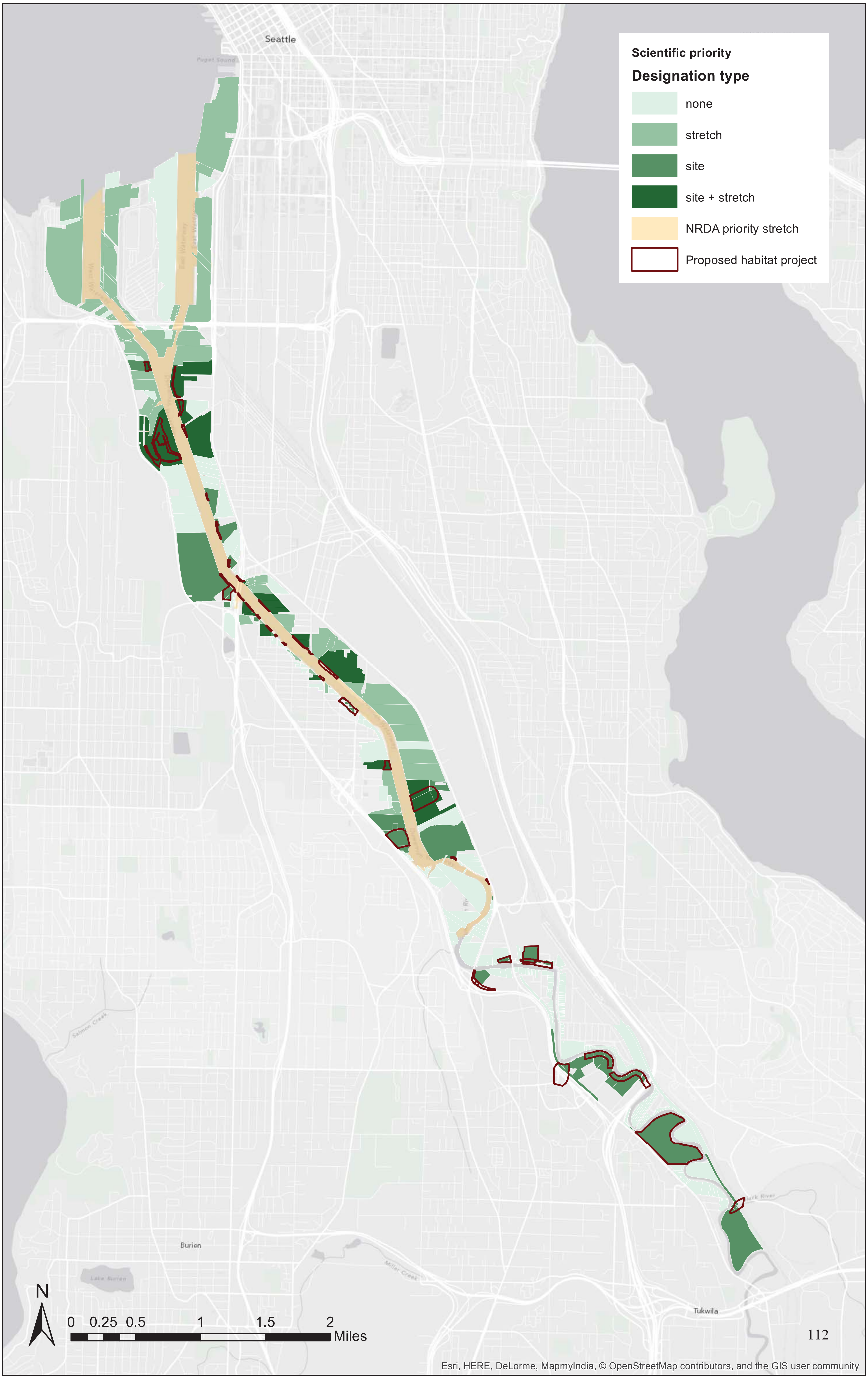
4.2.4 Maps of ecological and social metrics

Maps of each metric and of the overall ecological and social indices are presented on the following 15 pages.

Designated by a science-based plan as a priority area for restoration

E1

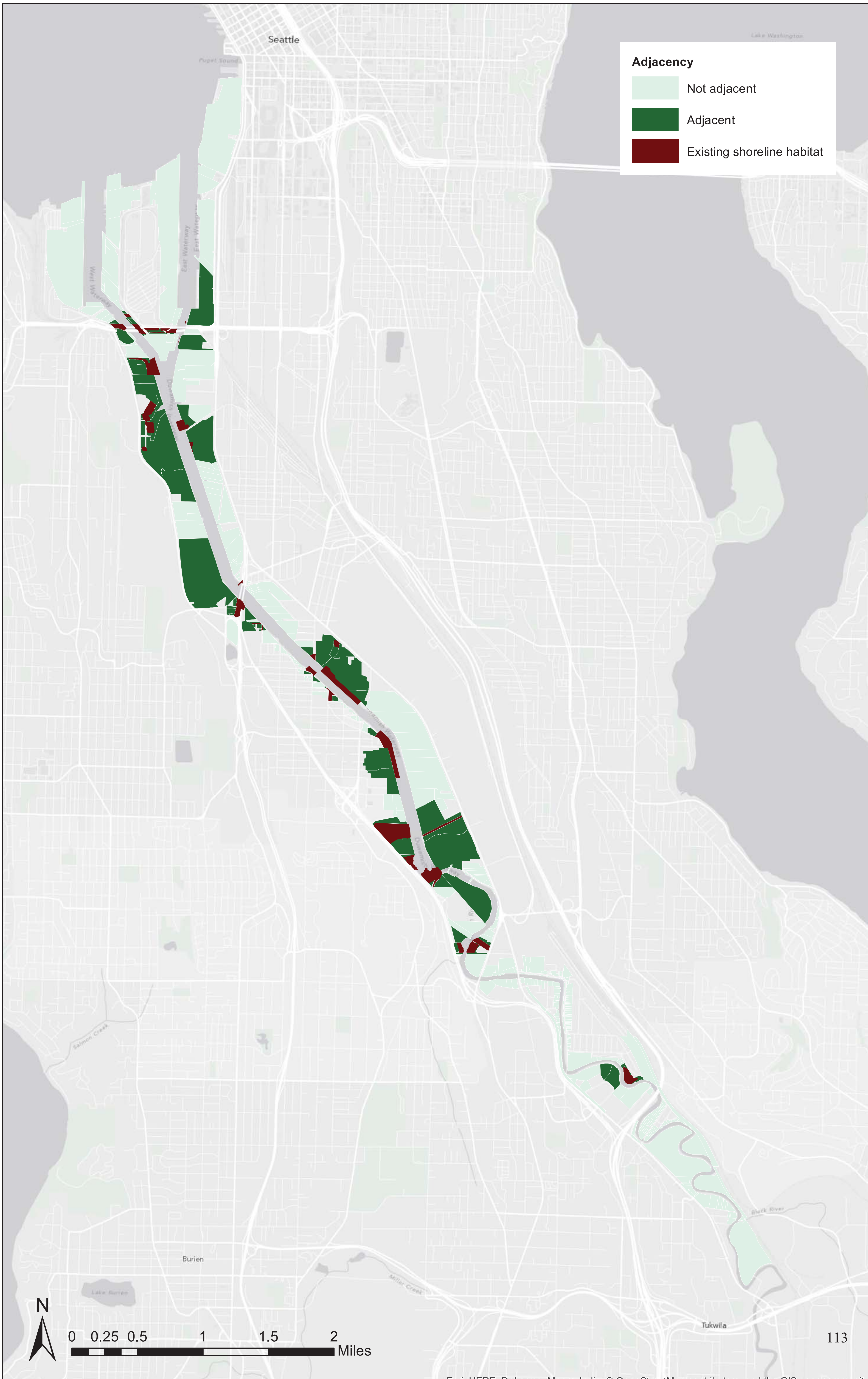
Ecological metric: Scientific Priority



Adjacent to or containing existing shoreline habitat

E2

Ecological metric: Adjacency

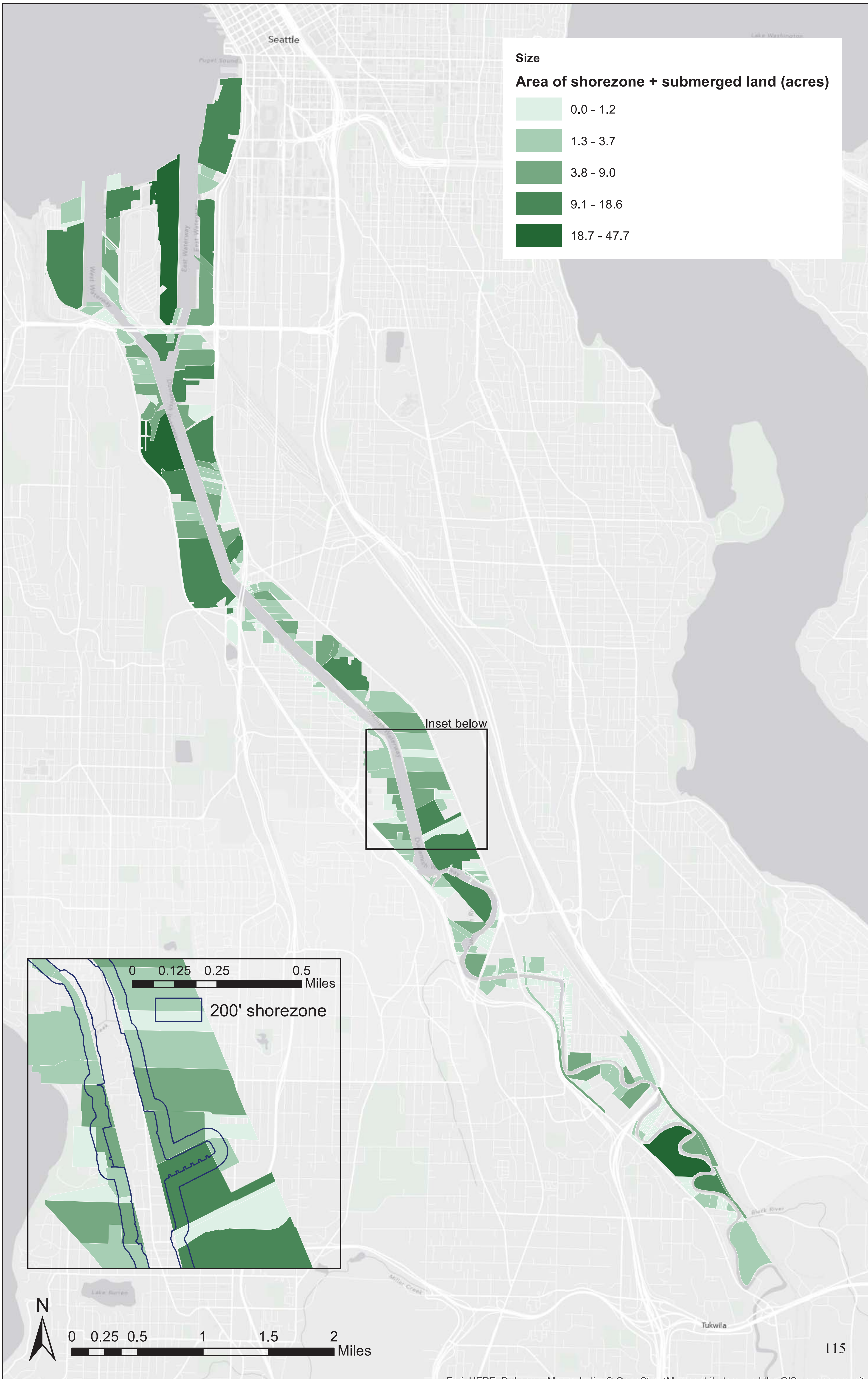


Habitat Distribution: Mean distance from existing habitat network

Ecological metric: Habitat Distribution

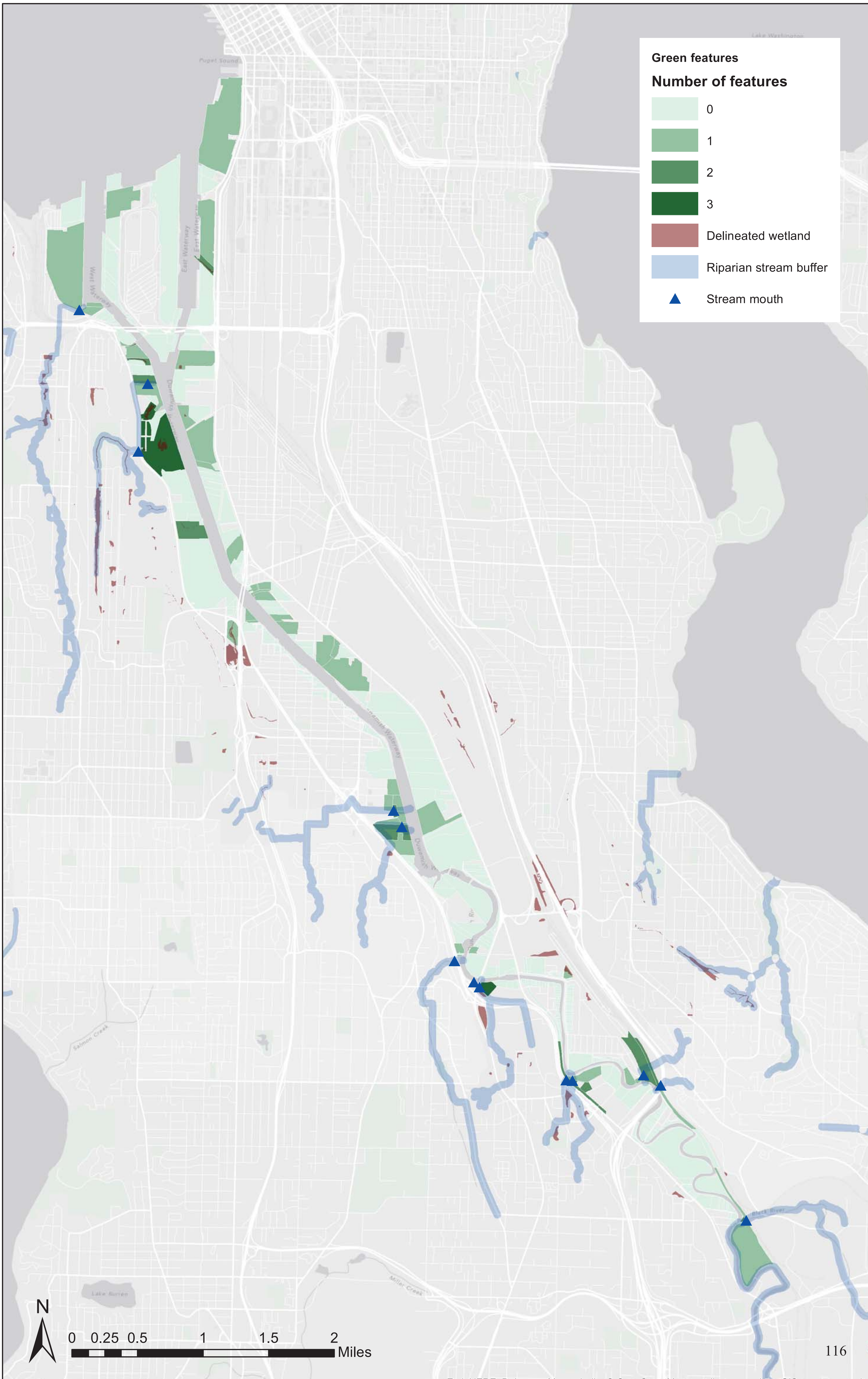
Area of shorezone and submerged land within the study parcel

Ecological metric: Size



Presence of ecologically beneficial features

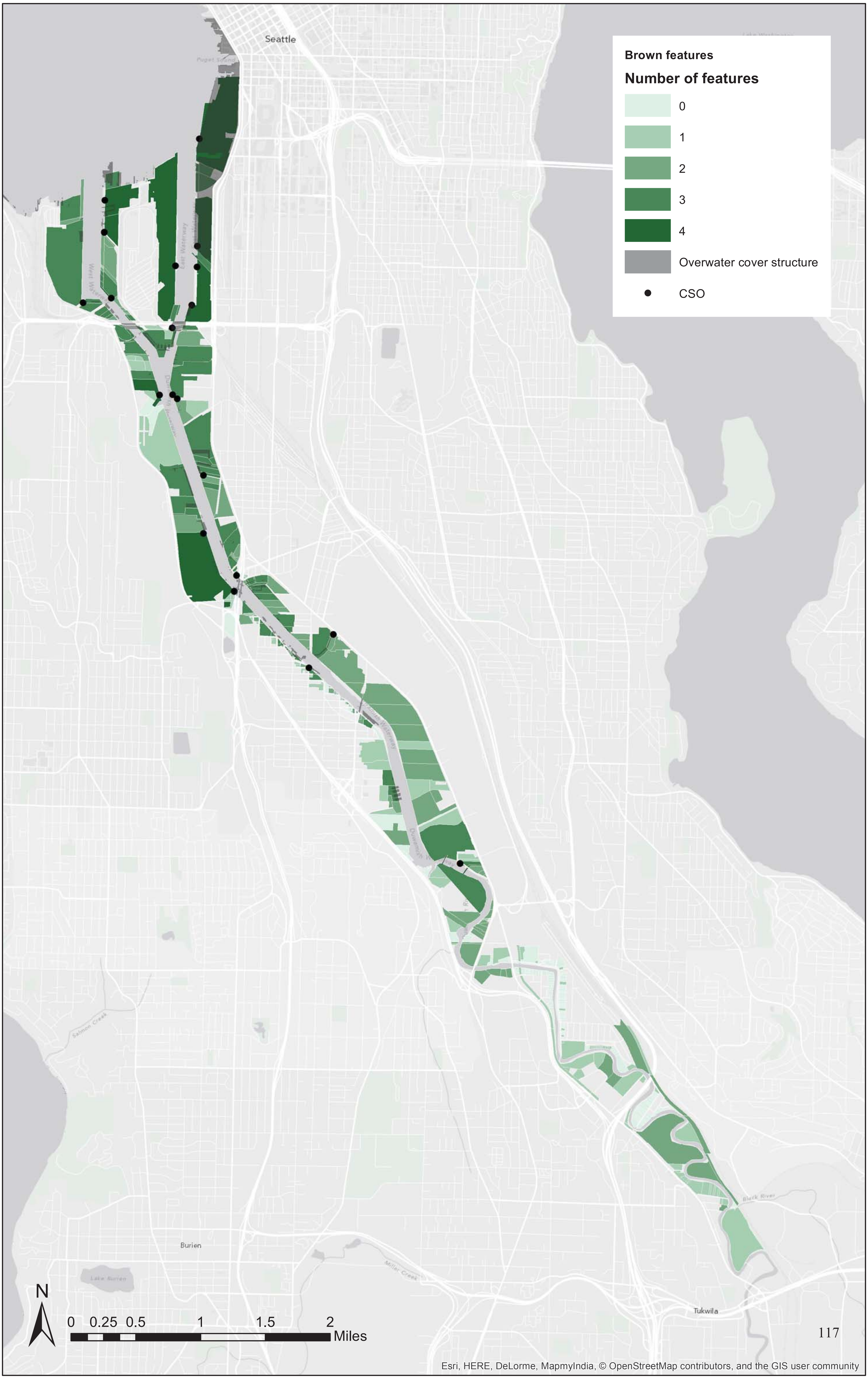
Ecological metric: Green Features



Presence of ecologically detrimental features

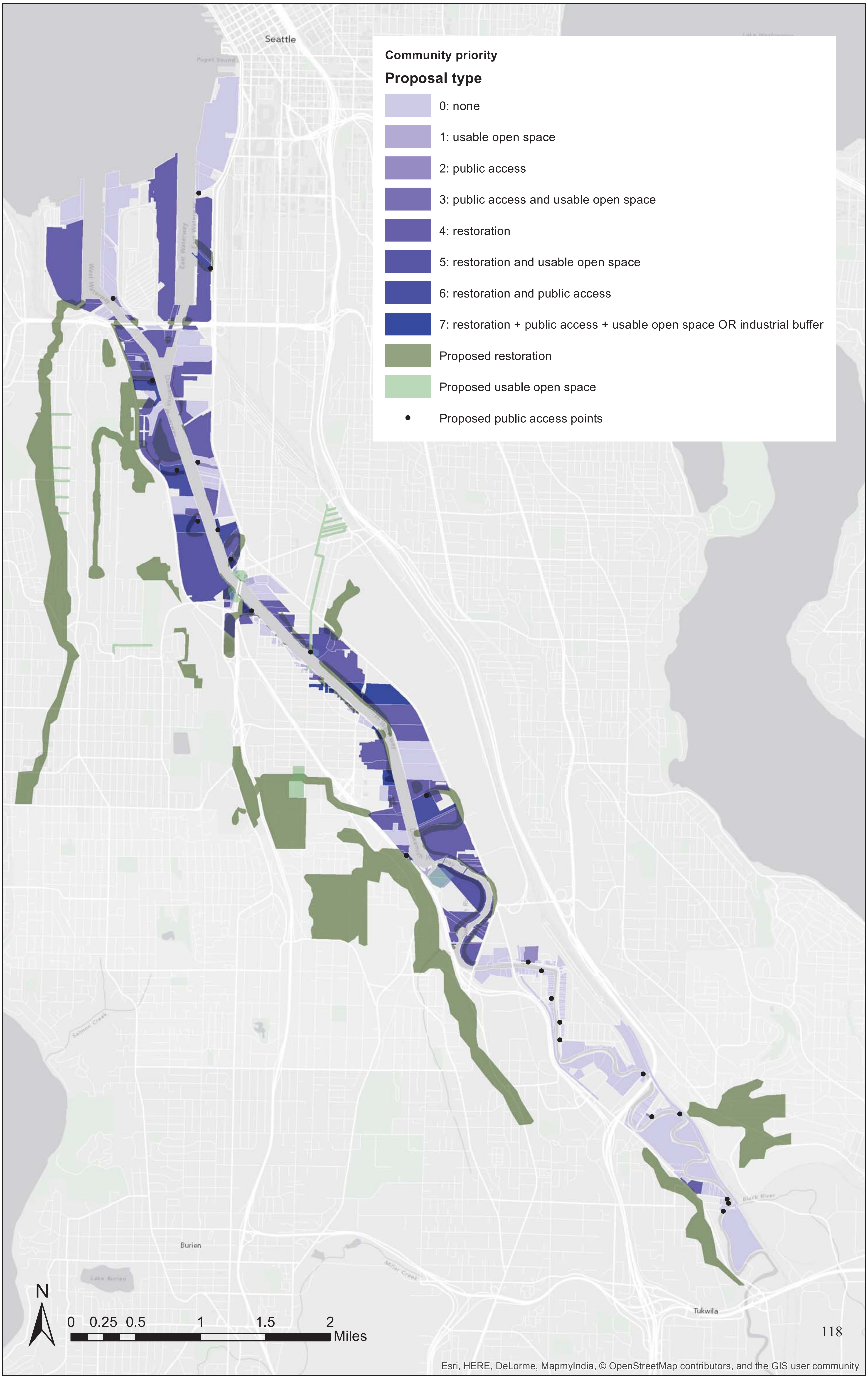
E6

Ecological metric: Brown Features



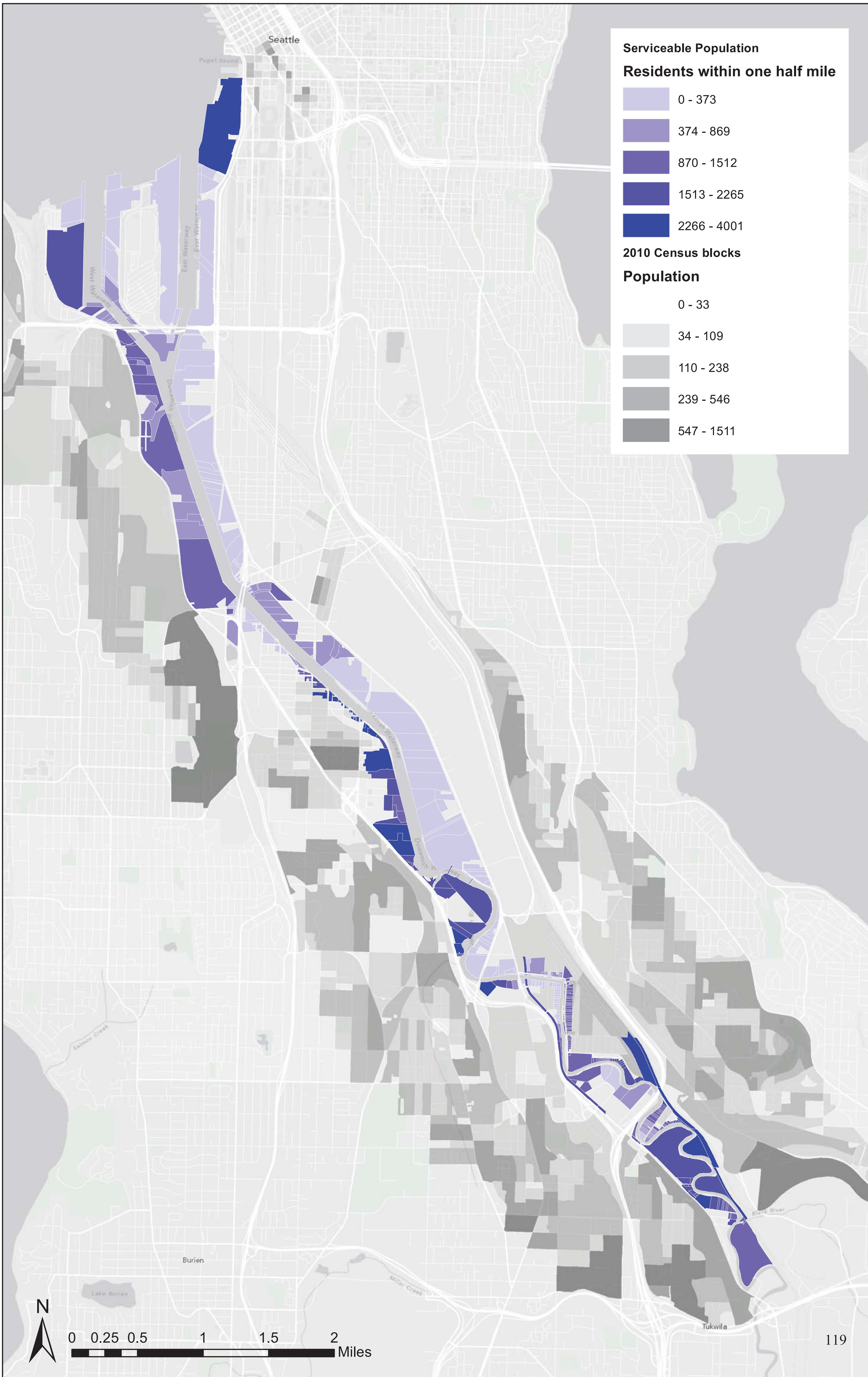
Proposed site for restoration, usable open space, or public access

Social metric: Community Priority



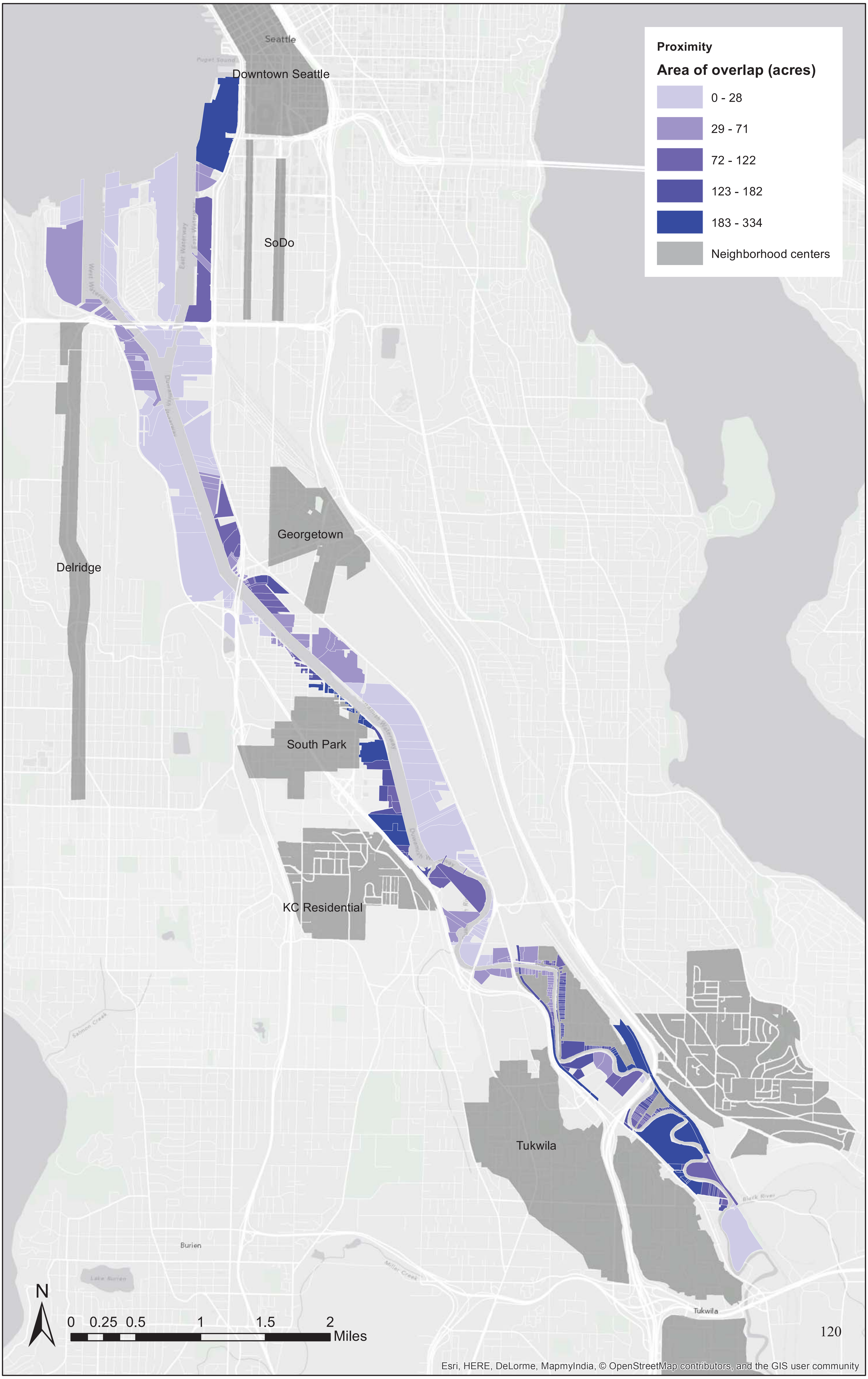
Population within a half mile of study parcels

Social metric: Serviceable Population



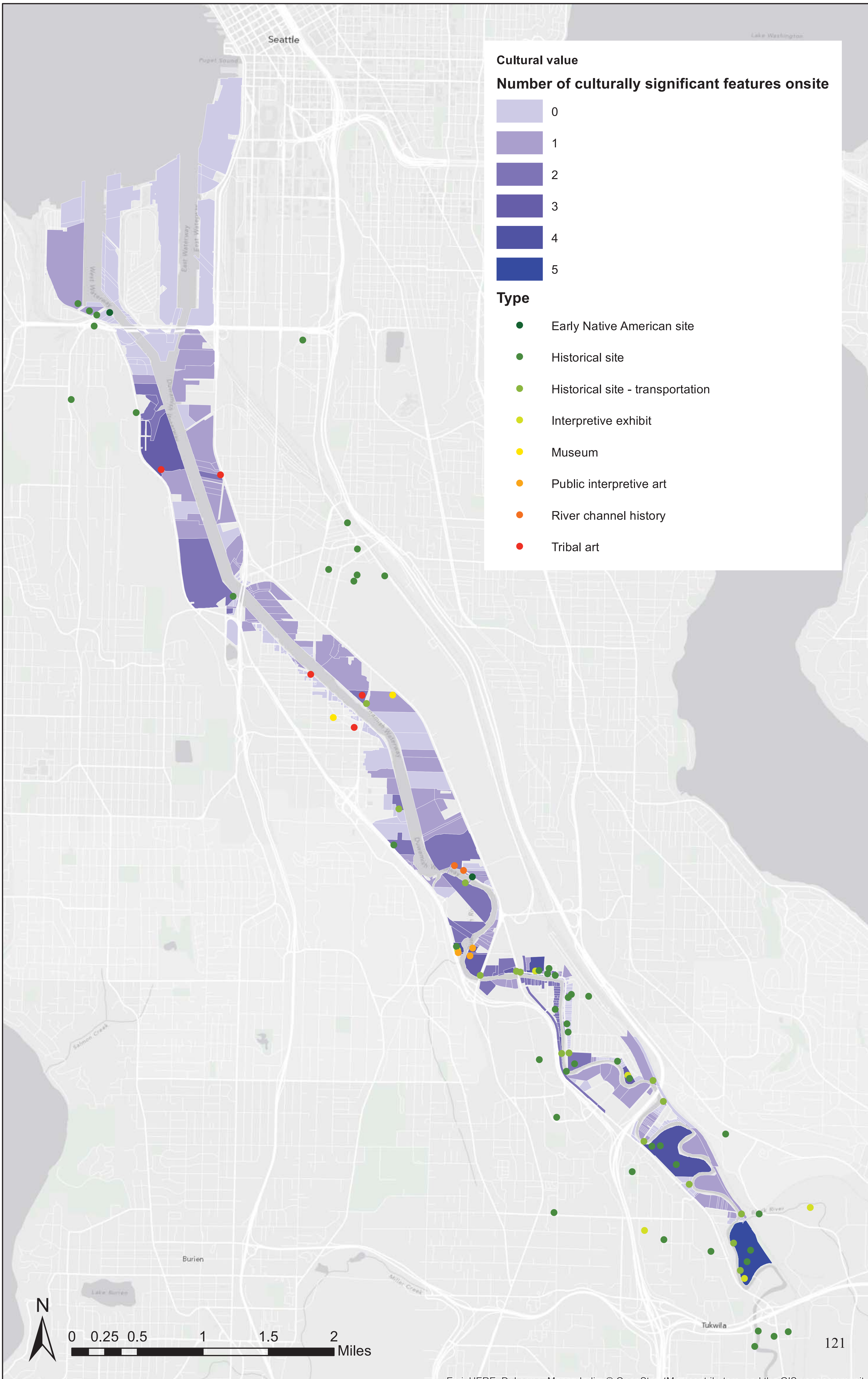
Proximity to neighborhood centers: Area of overlap with half-mile buffer S3

Social metric: Proximity



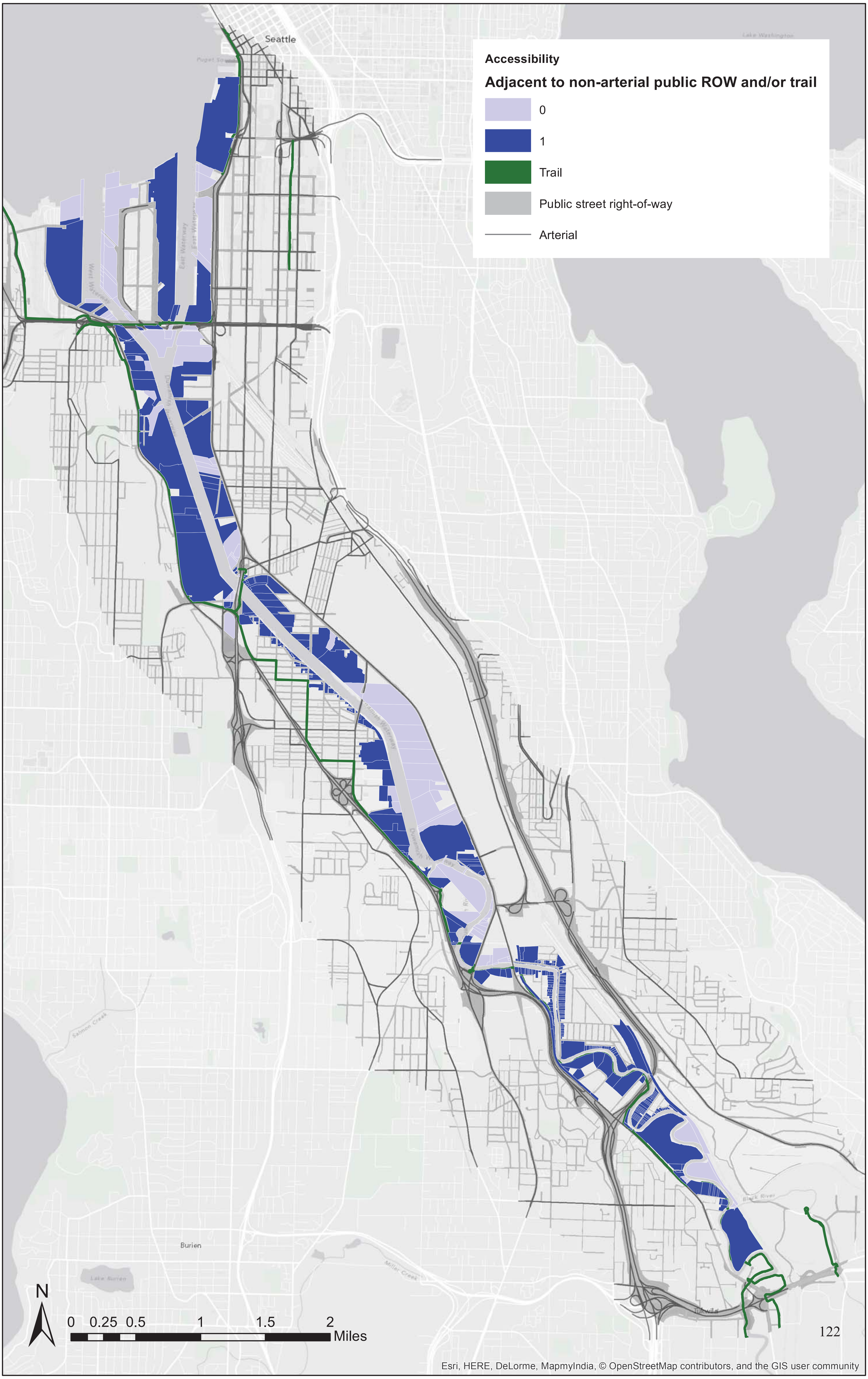
Number of culturally-significant features onsite

Social metric: Cultural Value



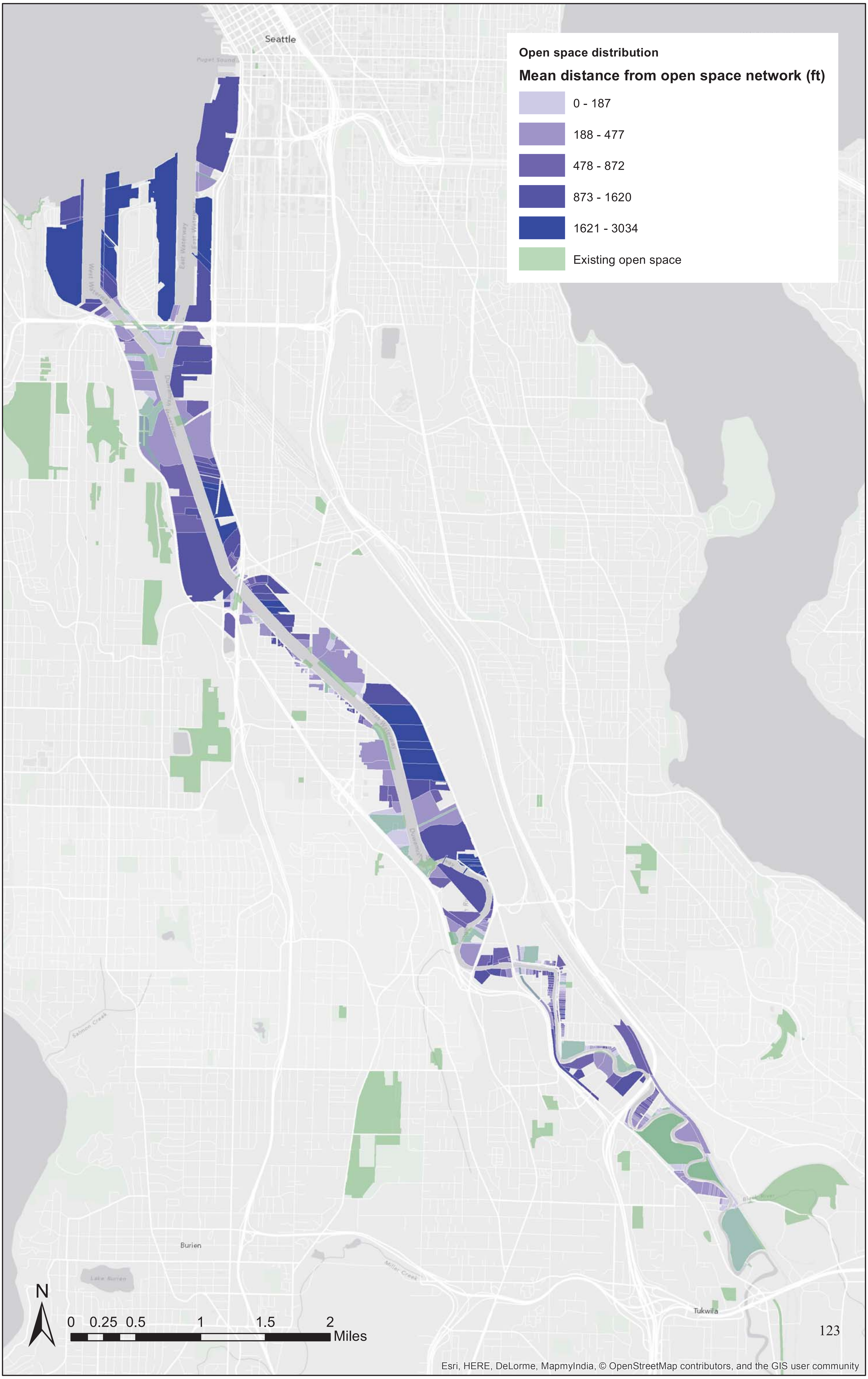
Adjacent to non-arterial public ROW, including trails

Social metric: Accessibility



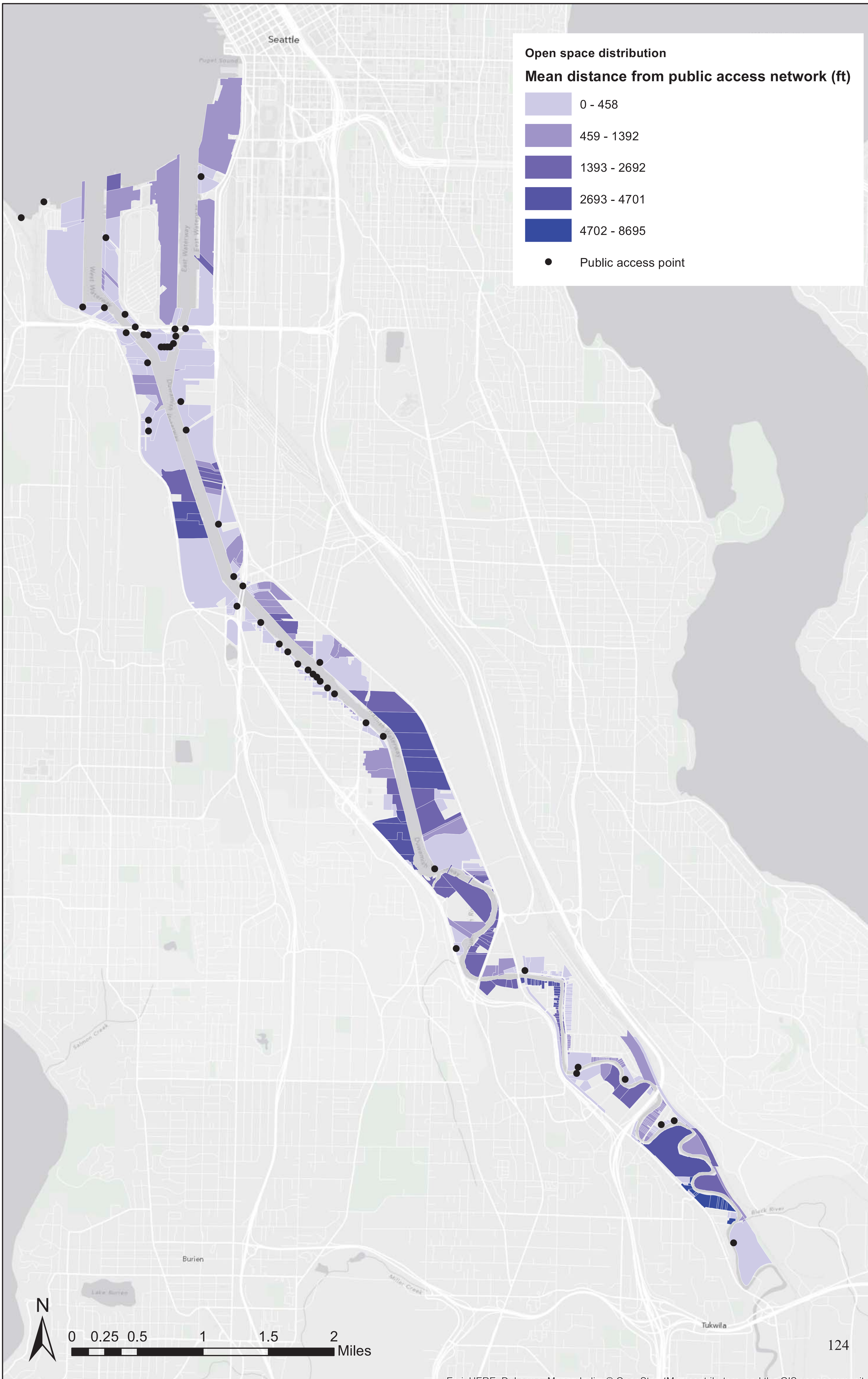
Open Space Distribution: Mean distance from open space network

Social metric: Open Space Distribution



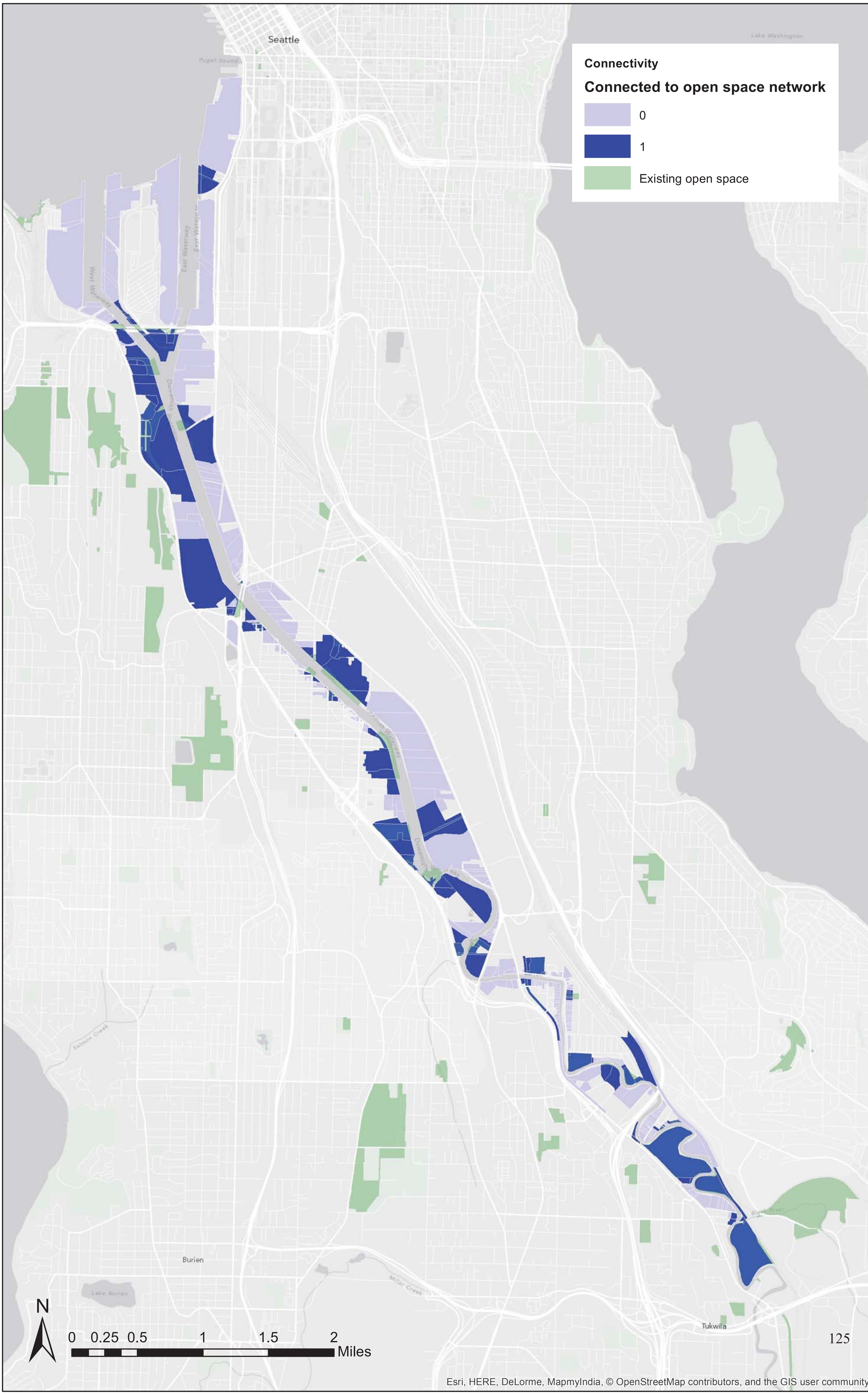
Public Access Distribution: Mean distance from public access network S7

Social metric: Public Access Distribution

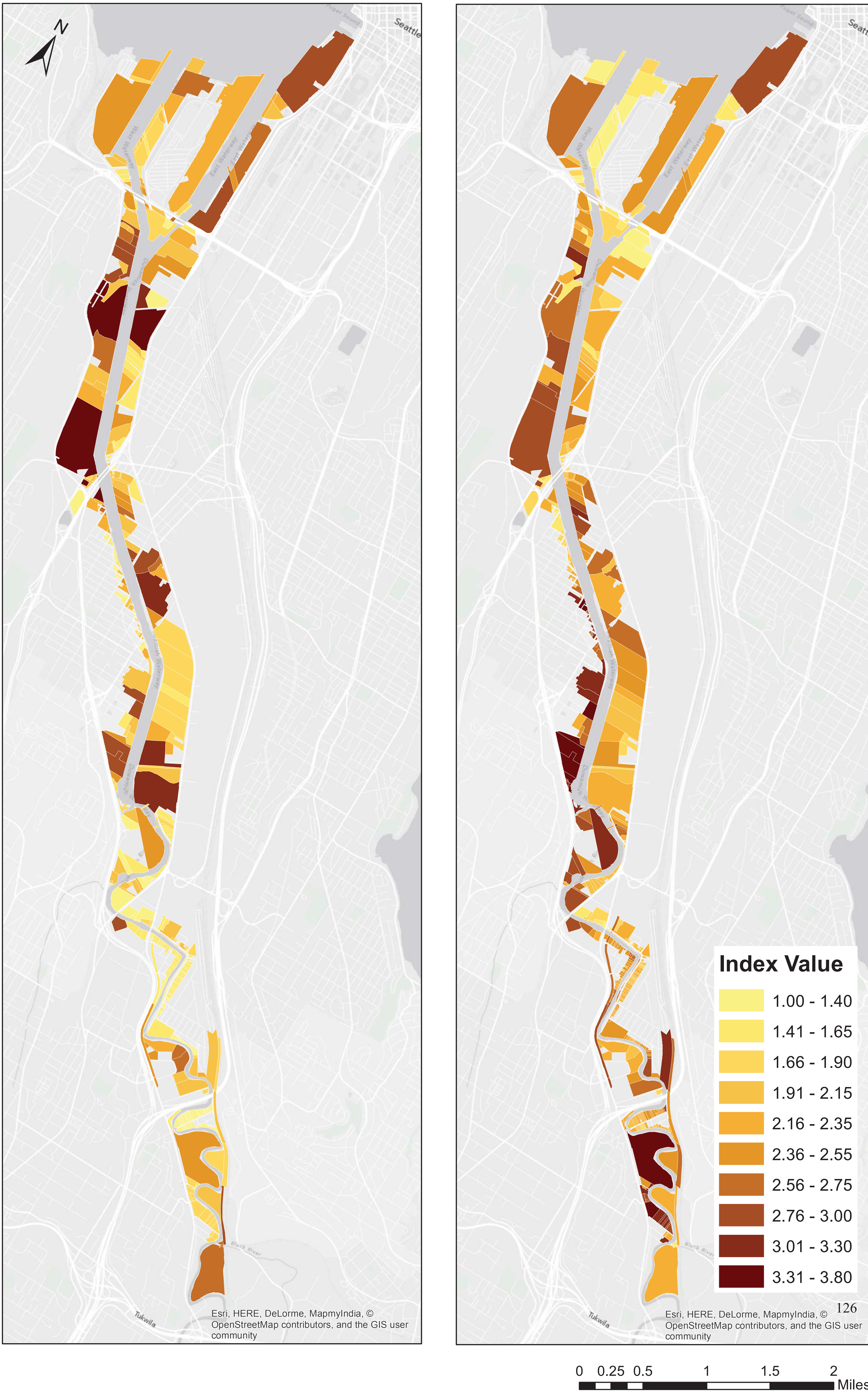


Connected to existing open space network, including habitat

Social metric: Connectivity



Ecological Value Index | **Social Value Index**



5 Discussion

5.1 Validation of conceptual models

Both conceptual models developed in Phase One of this research show general agreement with the academic literature. Numerous efforts use suitability analysis in GIS to evaluate potential restoration sites.[156] Like my ecological conceptual model, these emphasize the site and network scale. At the site scale, several of these efforts name edge density, or total edge, as well as appropriate elevation gradients, as contributing to ecological value.[157] These characteristics are incorporated into LDR restoration evaluation primarily through Habitat Equivalency Analysis, along with size, habitat type, and other site-specific characteristics.[158]

At the network scale, academic literature confirms the importance of habitat connectivity and distribution "…to ensure that the biological and physical longitudinal connectivity of 'bio-highways' are preserved, enhanced, and maintained."[159] One area in which the conceptual model departs from pure restoration ecology is in its application of the system-scale evaluation of shoreline conditions. Restoration ecologists would assign lowest priority to the most highly degraded stretches based on their reduced chances of success.[160] Ecological plans for the LDR, however, assign those stretches the highest priority. This reversal is a direct product of the regulatory context of restoration in the LDR, which requires "on-site, in-kind" compensation of lost natural resources.[161]

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[156] Kunert, 2005; Kauffman, 2007; Diefenderfer et al., 2009; etc.
[157] Coastal Services Center, "Coastal Ecosystem Restoration," 2014.
[158] NOAA, "Final LDR NRDA Restoration Plan and Programmatic EIS," 2013.
[159] Findlay and Taylor, "Why Rehabilitate Urban River Systems?," 2006.
[160] Buckley and Haddad, "Socially Strategic Ecological Restoration," 2006.
[161] Washington Administrative Code (WAC) 173-27: Shoreline Management Permit and Enforcement Procedures (2011).

Validation of the social conceptual model is less straightforward. Within the academic literature, studies tend to focus on one aspect of social value and describe it in detail. For example, Che et al. explore the dimensions of public access, including spatial openness, visual continuity, corridor continuity, and provision of amenities. These dimensions are combined in a single "Public Accessibility of Riverfront (PAR)" index.[162] The existence of such studies and indices is in itself a validation of the social value of, in this case, accessibility and provision of public shoreline access. These studies are applicable "when the ultimate scale (project size) and layout are in dispute."[163] Considering their application in the LDR, they demonstrate the need for more specific and accurate information about the predicted effects – both social and ecological – of restoration.

Other research within the planning literature asserts the value of public programming for education and outreach, regardless of the physical design of the site. These elements "activate the space," encouraging human use and interaction.[164] Independent of site selection, these site-level characteristics, together with public involvement, are crucial to create a sense of ownership of the site.[165] In general, the social conceptual model emphasizes the importance of green spaces that preserve uniqueness and identity while integrating with their surroundings. This emphasis is supported in the planning literature, which highlights the importance of a sense of place, not only for restoration projects, but also for urban renewal projects and urban development in general.

5.2 Limitations of methodology

With 511 parcels included in the spatial analysis, validation of each metric on an individual parcel scale is not feasible. However, the general spatial and numeric trends for both

[162] Che et al., "Assessing a Riverfront Rehabilitation Project," 2012.
[163] Buckley and Haddad, "Socially Strategic Ecological Restoration," 2006.
[164] Orr et al., "Citizens' Views on Urban Revitalization," 2002.
[165] Dyson et al., "Planning and Management Guidelines for Coastalscape Revitalization" 2013.

the ecological and social indices, as described in Section 4.2, are consistent with the conceptual models for overall ecological and social value. For example, social values tend to be higher farther from industry and closer to where people live, while ecological values are more dependent on the site-specific conditions that determine potential ecological lift. The parcels with the highest scores for ecological value, such as the Port's Terminal 107, Terminal 108, and Terminal 25, and the Boeing Development Center, are validated somewhat by current work by the Port of Seattle and Boeing to evaluate or plan for compensatory habitat restoration on each parcel.[166] However, across the entire LDR, index values are not as variable as expected for either ecological or social value, resulting in less distinction between parcels. Although the spatial analysis approach matches the scale of restoration planning in the LDR, and is intended as a proof of concept, there are several limitations that influenced Phase Two results and should be acknowledged.

Data quality and consistency

As with most sizeable spatial analysis projects, data availability, quality, and consistency limited both the methodology and the results. LDR-wide data sets were harvested primarily from publicly-maintained databases, with supplementing data sets digitized manually. At this scale, outdated, inaccurate, and incomplete data were inevitable. Spatial analysis at this scale is much more vulnerable to data inconsistencies. More importantly, the analysis is limited to the lowest resolution and level of measurement used. In application of the linear additive model, this resulted in the combination of data at several different levels of measurement into a single index – a process that results in significant loss of information. Furthermore, the data are sometimes insufficient to capture the subtleties of the phenomena being studied. For example, adjacency to

[166] Seaport Planning Group, "Portfolio of Habitat Initiative Projects," 2014.

existing habitat was operationalized as a simple polygon intersection: those parcels with borders touching restoration sites received the highest score for the adjacency metric. In the case of a large parcel owned by WSDOT, this approach failed to tell the whole story: though separated from the waterfront restoration site by a road, a large wetland occupies the parcel. The wetland is hydrologically connected to the restoration site, and therefore to the river, through a culvert underneath the road (Figure 5-1). The WSDOT parcel should rightfully receive a higher value for adjacency than a parcel that is completely disconnected from surrounding restoration. However, data limitations prevent that kind of specificity at the scale of the entire LDR. A more lenient definition of adjacency might use a buffer distance, for example, but such a distance is not defined in any of the ecological plans.

Figure 5-1: Map showing WSDOT wetland parcel across the road from existing restoration.

Subjectivity and researcher bias

The WSDOT example brings to light a more systemic problem of subjectivity. Some level of subjectivity is inherent in any MCDA problem: "Any system in which points are assigned imposes a normative framework on the analysis, as points are given based on what is perceived as a desirable outcome."[167] I developed a rigorous methodology including several layers of criteria in order to minimize subjectivity and ensure that value judgments came only from the regional plan analysis. However, the process of defining and operationalizing metrics required significant decision-making, most of which had to come from my expertise rather than from the literature. I attempted to be as objective and consistent as possible, but in any spatial analysis problem -- particularly one that employs Esri software – there are countless ways to accomplish each task. Some decisions are larger than others, but every decision adds imprecision to the model. Thorough documentation of my methods, which are supplemented by the appendices to this document, helps mitigate this imprecision, but does not eradicate it. Recommendations for future or related work include developing each metric in iterations, and performing sensitivity analysis on the linear additive models that combine each metric into an index value. In addition to ensuring robustness of the models, this would provide further information on the relationships between metrics in the models.

Dynamic change

A fundamental shortcoming of performing spatial analysis is that it inherently lacks a temporal component. In other words, it provides only a snapshot in time, while in reality the system it describes is constantly changing. For example, demographic changes have occurred between the two census data collections in King County and South Seattle, reflecting an increasing population that is increasingly urban and increasingly segregated.[168] Transportation and other infrastructure are also changing according to Capital Improvement Project schedules determined years ago. These trends and the speed of change in the LDR shape neighborhood

[167] Dyson et al., "Planning and Management Guidelines for Coastalscape Revitalization," 2013, 52.
[168] EPA, "Environmental Justice Analysis," 2013.

identities as well as planning efforts. The plans included in the regional plan analysis are updated regularly, on unrelated and overlapping cycles of three to ten years. While any system-scale analysis like this one cannot keep pace with these changes, they ultimately inform site-scale planning efforts that are much more sensitive to such changes. Incorporating public involvement into such site-scale efforts can further help projects stay relevant.[169] Entities performing restoration should also keep a regularly-updated database of variables important to their own decision-making processes. Relative to data collection and preparation, spatial analysis can be performed quickly in response to rising need.

In addition to variables incorporated explicitly into the various metrics, extraneous variables that change over time may play an important and unpredictable role in both social and ecological outcomes of habitat restoration. Climate change, regional population, public health, and culture are all examples of such extraneous variables. For example, sea level rise associated with climate change may dramatically alter the existing distribution of habitat, necessitating an ongoing assessment of new habitat needs for ecological benefit. Similarly, residential patterns may change, making certain locations more desirable for new green space. Prior to application for a given project, a sensitivity analysis should be performed that assesses each metric's robustness relative to relevant extraneous variables, and addresses uncertainties associated with how those variables may change over time.

[169] Dyson et al., "Planning and Management Guidelines for Coastalscape Revitalization," 2013.

5.3 Recommendations for application

5.3.1 Addressing trade-offs

In order to be included in the final framework, metrics were required to be unique and "not accounted for by any other metric."[170] Each metric was developed to capture a distinct component of social or ecological value, important in its own right as part of the overall framework. However, this approach could not preclude all relationships between metrics. For example, serviceable population and proximity each provide a different type of information: a restoration site contributes more social value if more people live within walking distance of it, and also if it is centrally located. The two metrics are inherently directly correlated, as neighborhood centers form where people live. Results from Phase Two also show several metrics with confounding relationships. For example, parcels located next to existing restoration sites score the highest on adjacency, but by definition also score the lowest on habitat distribution. The analogous metrics for social value – connectivity and open space distribution – show the same inverse relationship. This relationship reflects a continuous struggle between two dominant concepts in restoration ecology: the benefit of large habitat "hubs," and the importance of a network of habitat "corridors."[171] At the system scale, both are important for a functioning ecosystem; however, deciding between the two must occur on a site-by-site basis.

These confounding relationships are also evident across conceptual models. In other words, certain features that make a restoration site more socially valuable may make it less ecologically successful, and vice versa. For example, most of the social plans direct restoration and open space development outside of industrial areas, citing concerns for public safety and economic vitality. These industrial areas are generally the most degraded stretches of the LDR,

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[170] Section 3.2.3.1, this document.

[171] Seaport Planning Group, "Lower Duwamish River Habitat Restoration Plan," 2009.

and are therefore identified by ecological plans as areas that could bring the most ecological value through habitat restoration. Similarly, social plans cite proximity to a large residential population as a source of social value. However, both social and ecological plans suggest that public access to habitat may reduce ecological success. While the social benefits of human interaction with nature in an urban environment are widely documented,[172] the ecological implications – positive or negative – are poorly understood. More research is needed on how to maximize social utility in urban restoration projects without compromising ecological integrity – if ecological integrity is compromised at all.

Confounding relationships represent trade-offs between different valuable characteristics. Use of the linear additive model addresses such trade-offs through relative weighting of these characteristics. For example, good performance on a heavily-weighted criterion can in principle compensate for weaker performance on another, less-heavily weighted criterion.[173] In reality, some trade-offs represent fundamental conflicts that are not differentiated effectively in the model. This is the case with habitat connectivity and distribution; in both the ecological and social models, the difference between each metric's weight is only five percent. Furthermore, the two models together do not address the important trade-off between overall ecological and social value. This is not a failure of the approach; in multi-criteria decision analysis, a unique optimal solution does not typically exist. Instead, the MCDA "solution" is a set of optimal alternatives. A human decision-maker must select the most preferred solution from among these.[174] Therefore, the site selection framework developed by this research is only valuable as applied by a human decision-maker with a real set of project-specific preferences.

[172] European Centre for River Restoration, 2013; ECONorthwest, 2012; Center for Environmental Economic Development, 2005; etc.
[173] DCLG, *Multi-Criteria Analysis*, 2009.
[174] *Ibid.*

Accordingly, entities applying this framework should roughly follow a six-step process:

1. Define the restoration objectives specific to the project, as well as the relative importance or priority of these objectives. For example, a project may define its primary objective as restoring natural beach processes to an urban waterfront parcel, and its secondary objective as providing physical water access for residents of the surrounding neighborhood. For such a project, ecological value will take priority over social value.
2. Use the framework to create a short (three to five) list of candidate sites. Apply any additional filters according to projects-specific feasibility considerations, such as land ownership, to further reduce this list.
3. Examine the individual components of the framework (metric values) for the candidate sites, together with any relevant outside data or information, to look for opportunities to improve ecological or social value. Develop conceptual-level plans or designs for each candidate site.
4. Using the conceptual-level plans, consult with stakeholders to more specifically define objectives and public values related to the project.
5. Using these stakeholder-developed objectives, select a site from the list of candidates.
6. Using information from all of the previous steps, design and activate the restoration project to achieve its social and ecological objectives.

As discussed previously, significant value can be added to a restoration project through site-scale design. In other words, site selection is not necessarily the only determinant of the ultimate social or ecological value of a project. The site selection process will have intentionally biased the site toward ecological or social value, so entities should look in particular for opportunities to increase value along the secondary dimension. For example, a project driven primarily by ecological objectives might find itself located far from residential populations. Such a project might increase social value by using volunteer coordination and education outreach programming to increase visibility and visitation rates. A project driven primarily by social objectives, on the other hand, might increase ecological value through planting of native riparian vegetation wherever possible throughout the site (e.g. Figure 2-3, Terminal 107 Park). Guidance for this kind of site-scale optimization can be found in many of the plans discussed as part of this research. For example, shoreline impairment analysis included in each SMP could indicate which ecosystem processes are most highly degraded on a given site. Restoration aimed at these processes would maximize ecological value at that site. This kind of site-specific guidance is beyond the scope of this research, but would provide a natural complement to it for use by restoration decision-makers.

In addition to optimizing value at the site scale, restoration decision-makers should look for potential synergies between ecological and social metrics. While this study did not reveal such synergies, they are likely to exist at the project scale. The lack of synergies observed at the system scale may be due in part to the way in which the regional plans were developed. With the exception of the SMPs, ecological and social plans were developed by separate institutions and separate efforts, with little to no overlap. The SMPs incorporate both ecological and social elements, but planned for them using separate processes. While future coordination of planning efforts might reveal potential synergies between ecological and social goals, the current system may perpetuate the perception of necessary trade-offs between ecological and social benefits.

5.3.2 Refining the model

As discussed previously, the conceptual models and the maps and calculations derived from them paint a picture of a moment in time. Each relationship within these models – each metric, and each connection between metrics and the overall model – should be treated as a dynamic, testable hypothesis. As such, each hypothesis should be tested and refined over time using the most up-to-date information and understanding of habitat restoration in the LDR. Data collection is fundamental to this approach. Federal and state regulations require that many restoration projects design and implement long-term monitoring plans. The monitoring must test for the ecological success of the project, and define steps to take if the project fails to meet certain ecological criteria. These monitoring plans present an opportunity to refine the conceptual models of ecological and social value in the LDR, and should incorporate relevant variables whenever possible. For example, together with physical habitat monitoring and species usage, project owners could monitor visitation rates and satisfaction of nearby residents and businesses to determine whether the project was introducing any social benefits to the neighborhood. In addition to variables included in the conceptual models, such monitoring efforts could track relevant extraneous variables, as discussed in the previous section. As with typical monitoring efforts, comparison between a suite of sites or with a reference site would yield the most understanding of ecological and social relationships, which could then be used to refine the conceptual models of restoration value in the LDR.

5.3.3 Longer-term recommendations

While restoration decision-makers often must navigate trade-offs between ecological and social value, they should also look for opportunities where the two can work together to produce a better overall project outcome. This research characterizes both ecological and social value directly from community-driven plans. Therefore the characteristics that increase the social value of a restoration project also improve the likelihood and magnitude of social support for that project. As discussed previously, social support, including a sense of ownership, pride, or stewardship, can both facilitate implementation of restoration as well as improve long-term ecological outcomes. However, this support is often dependent on the current state of the habitat, and of the environment as a whole.[175] In areas where the river or natural system appears healthy and functional, communities are more likely to be sympathetic toward ecological priorities, and therefore supportive of restoration efforts. Conversely, where the river is largely channelized and does not resemble a natural system, community restoration priorities are often focused on the social aspects of habitat restoration such as recreation and aesthetics.[176] Therefore as more habitat is restored and overall ecosystem health improves, social support increases. By looking for opportunities to incorporate community priorities into each project, restoration planners with ecological objectives can take advantage of this positive feedback loop and ultimately improve long-term ecological outcomes.

Restoration planners with social objectives also stand to benefit from the approaches employed by the scientific restoration community. As discussed previously, ecological plans tend to rely on analytical models or prioritization schemes to make restoration decisions, while social plan models are much more implicit and ambiguous. The restoration projects resulting from these plans also follow this trend. Ecologically-driven projects are often designed to produce a specific habitat function or value, which is calculated using a scientific method such as Habitat Equivalency Analysis.[177] Projects implemented without specific ecological objectives lack this kind of precision, and therefore often lack a way to measure success of any kind – ecological or social. Through development and application of more rigorous prioritization models, restoration planning efforts with social agendas – particularly those with ecological agendas as well, such as SMPs – could facilitate implementation and improve long-term success

[175] Findlay and Taylor, "Why Rehabilitate Urban River Systems?," 2006.
[176] *Ibid*.
[177]NOAA, "Final LDR NRDA Restoration Plan and Programmatic EIS," 2013.

of restoration projects. The spatial framework developed by this research is an attempt to do just that, but should be catered to suit the needs of each planning effort.

This research has focused on two broad aspects of habitat restoration in an urban estuary: ecological value and social value. In addressing these two aspects, it necessarily omitted countless other considerations related to restoration. Importantly, in focusing on early planning stages of restoration, it does not address the many significant implications and effects a restoration project has on the surrounding community for years to come. For example, recent work by Kaza and BenDor indicates that restoration decreases land values immediately surrounding the project, while increasing land values farther than a half-mile away.[178] In an urban industrial setting such as the LDR, these effects may be dramatic and have regional implications. Future research should consider economic value as a third, equal component alongside ecological and social value. Given the socioeconomic setting of the Duwamish Valley, future work should also address concerns of environmental justice. For example, while results show slightly higher potential social value in the southern portion of the study area, closer analysis of demographics and overall quality of life might indicate a stronger need in the neighborhoods immediately adjacent to the industrial core. Overall, this research is part of a growing body of research intended to increase understanding of the role of habitat restoration in an increasingly-urban world.

[178] Kaza and BenDor, "Land Value Impacts of Wetland Restoration," 2013.

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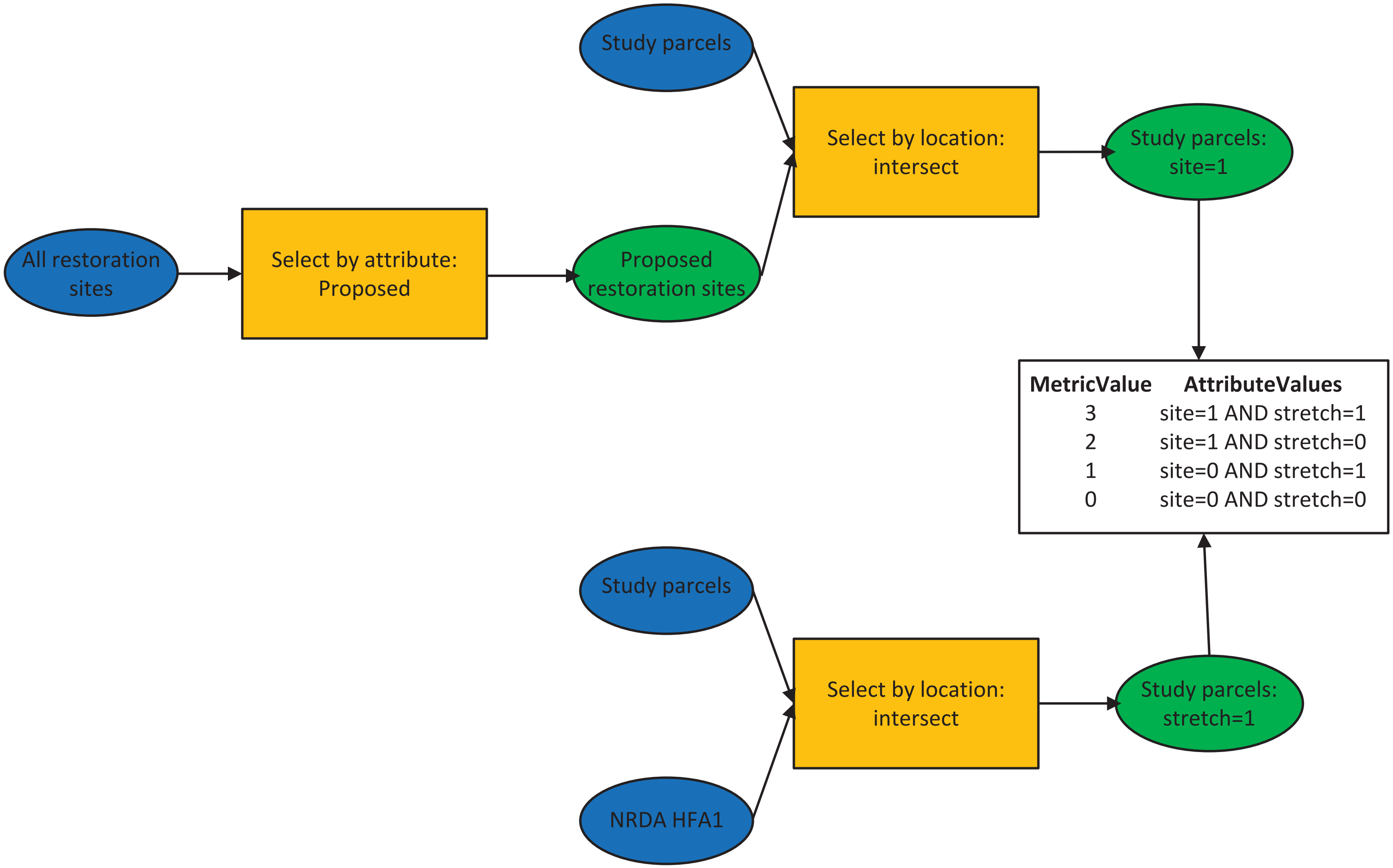
Appendix A
Methodology models

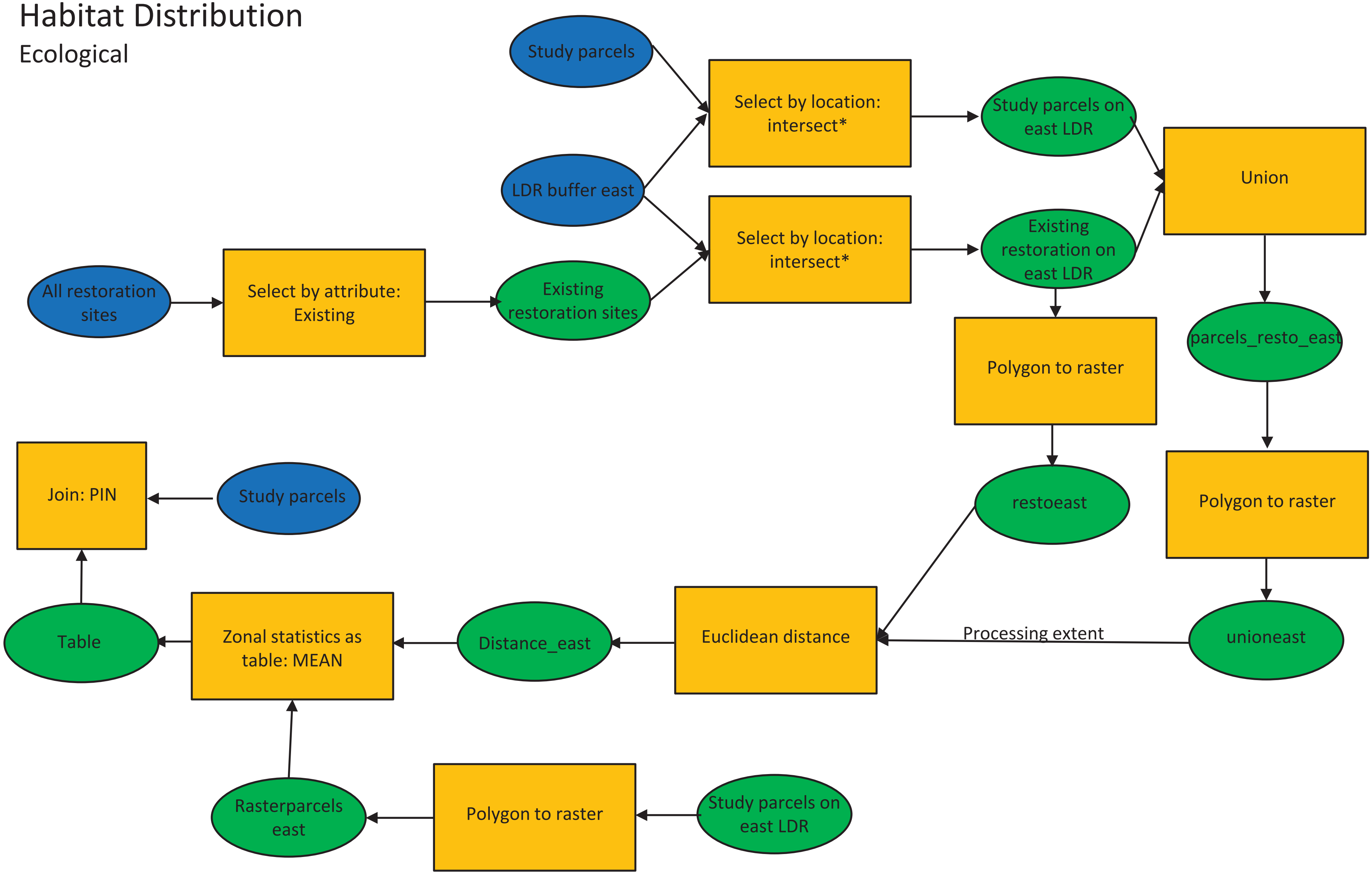
Scientific Priority
Ecological



Input data:
study_parcels.shp
Restoration_projects.shp
NRDApriority.shp

Habitat Distribution

Ecological

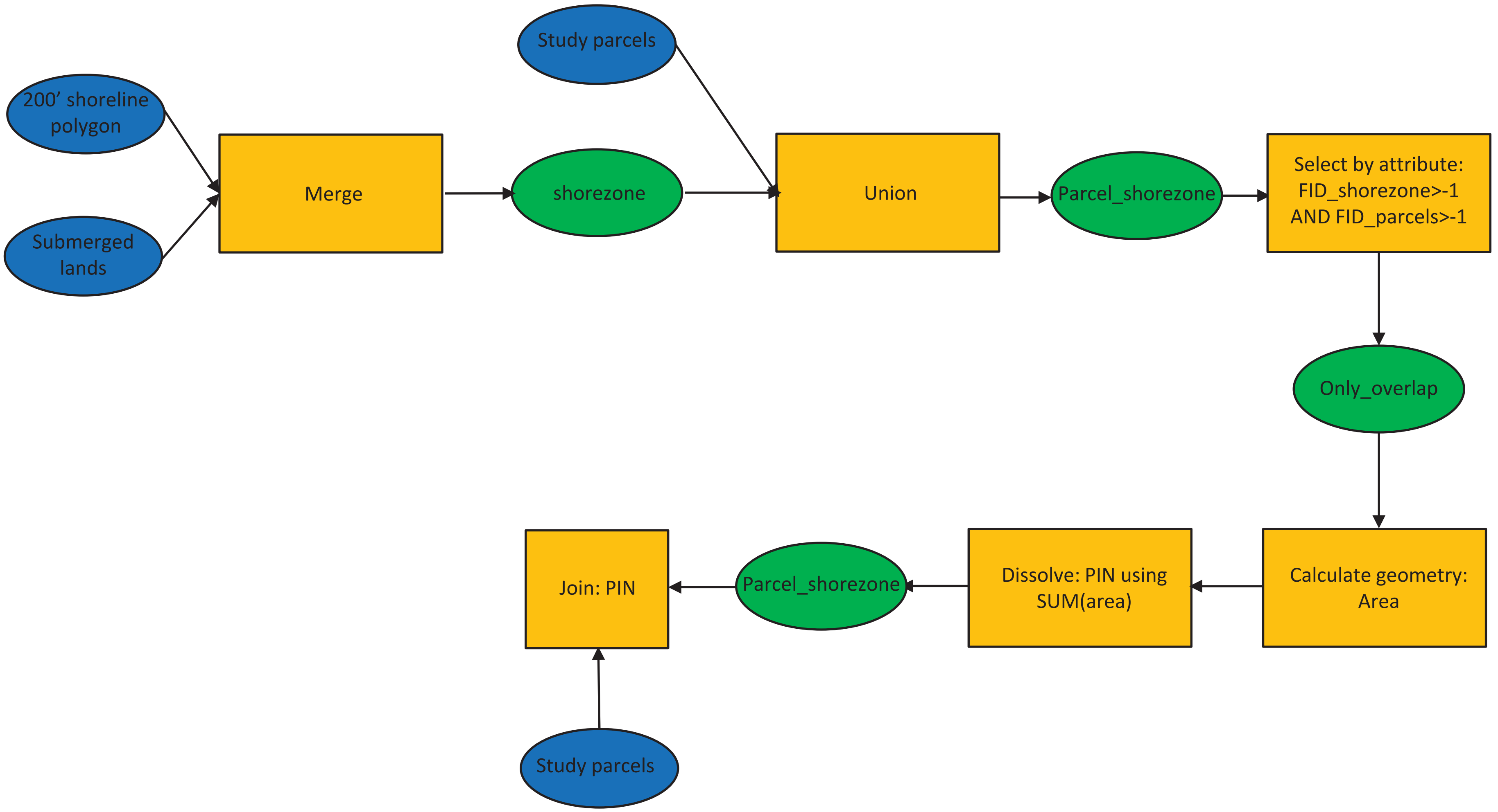


<u>Input data:</u>
study_parcels.shp
Restoration_projects.shp
LDRbuffer.shp

*Functions repeated for east and west halves of the LDR

Size

Ecological



Input data:

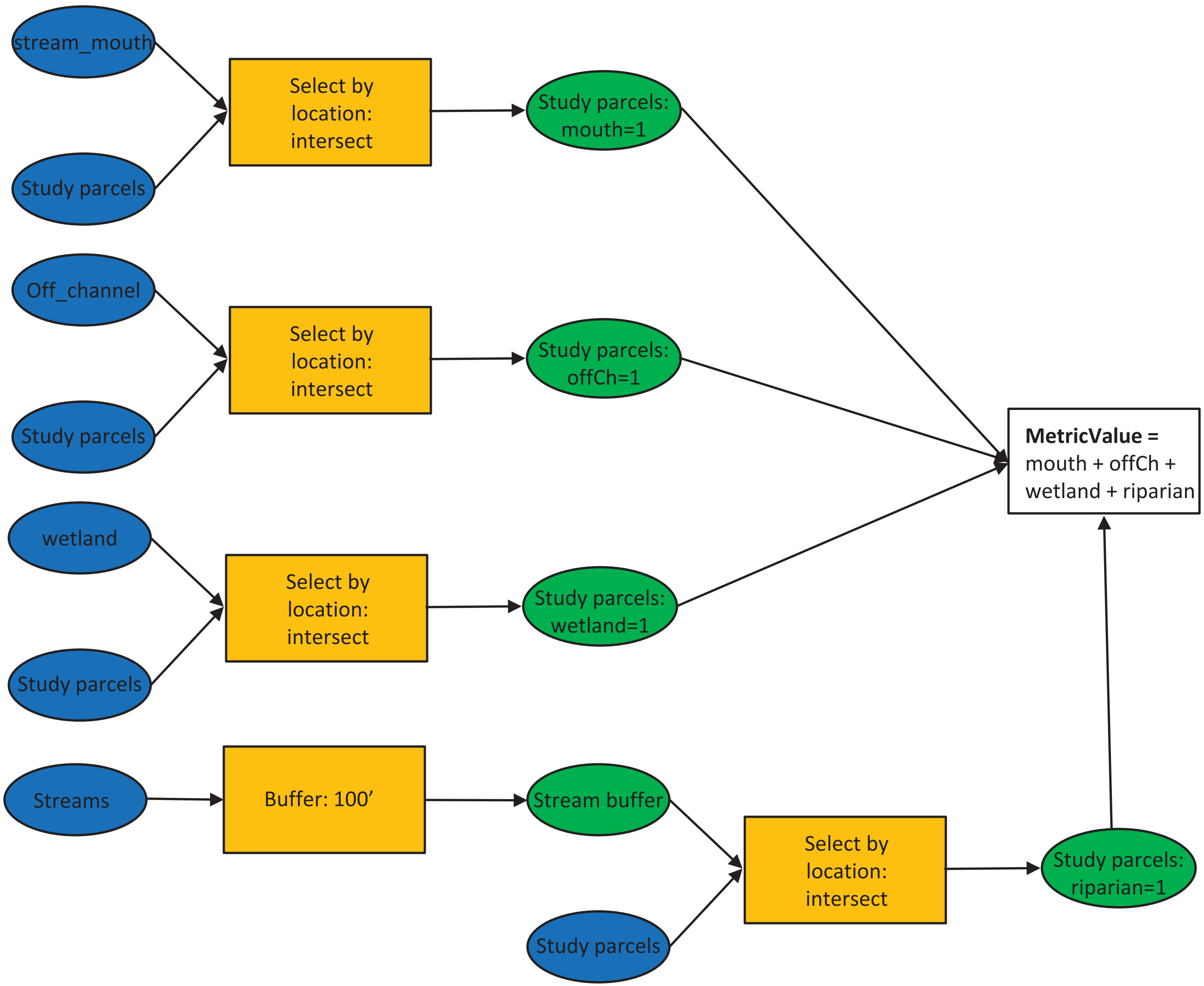
study_parcels.shp

LDW_shorezone_200ft.shp

LDW_shoreline.shp

Green Features

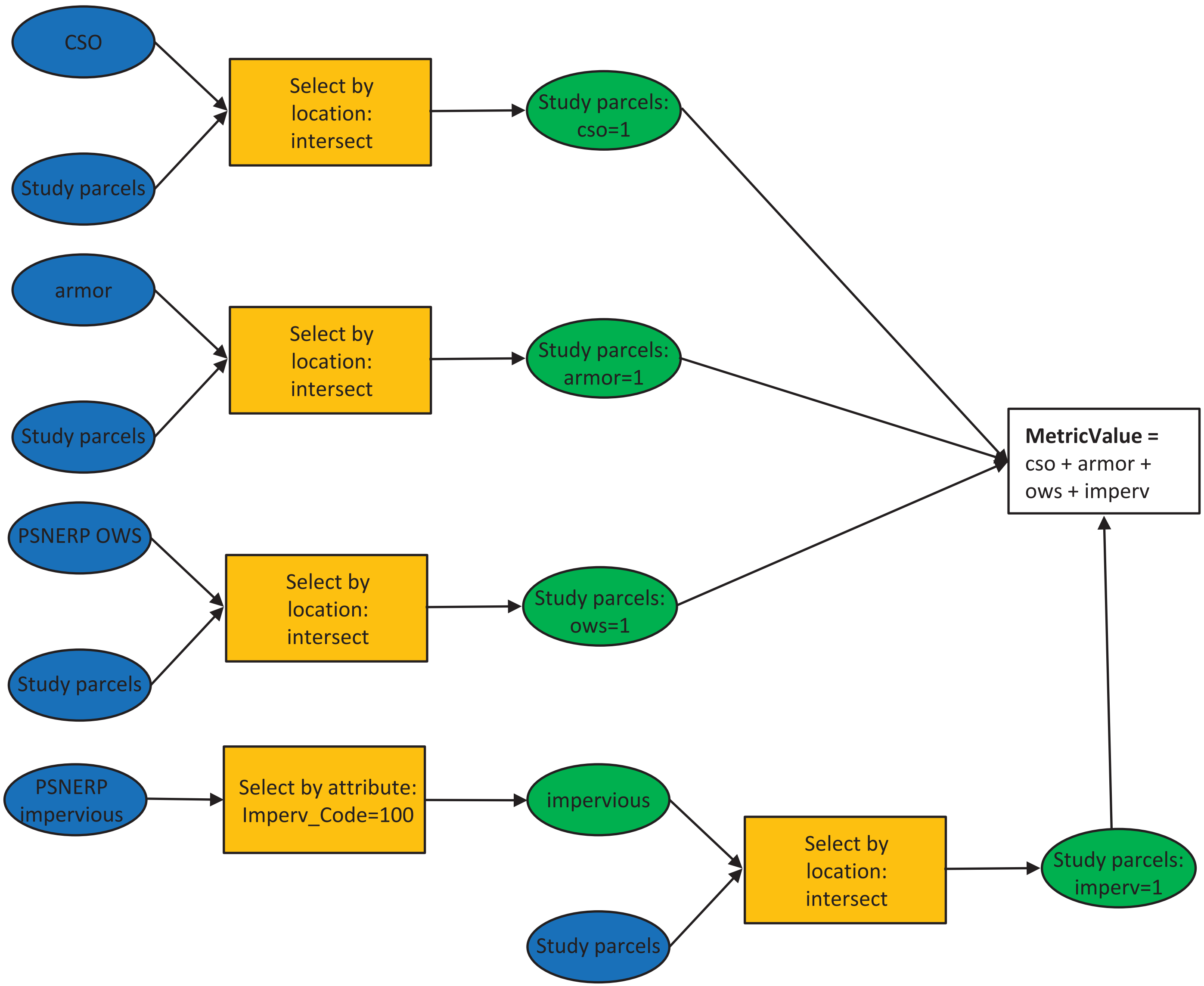
Ecological



<u>Input data:</u>
study_parcels.shp
stream_mouths.shp
off_channel.shp
LDRwetlands.shp
LDRstreams.shp

Brown Features

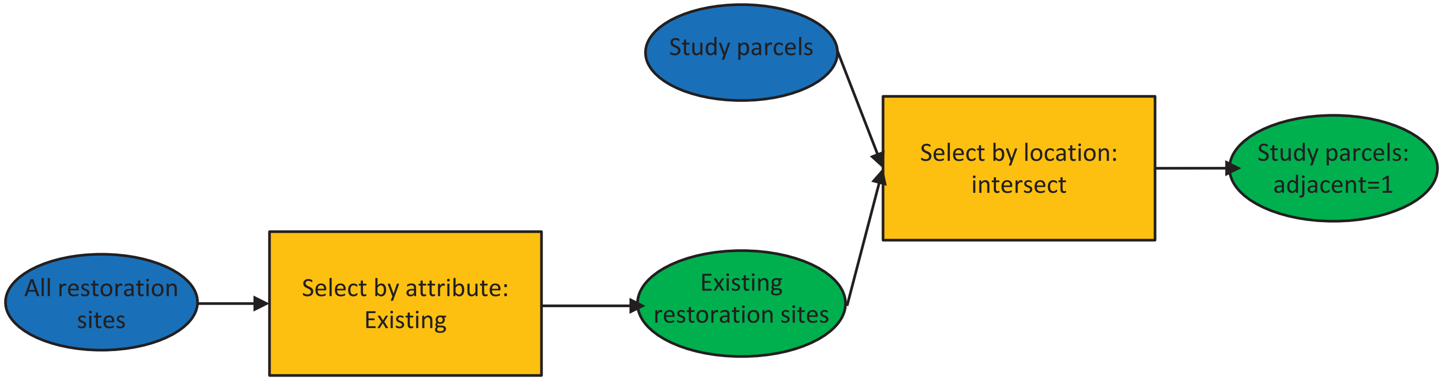
Ecological



Input data:
study_parcels.shp
CSO.shp
armor.shp
fd_OWS.shp
fd_impervious_T3.shp

Adjacency

Ecological



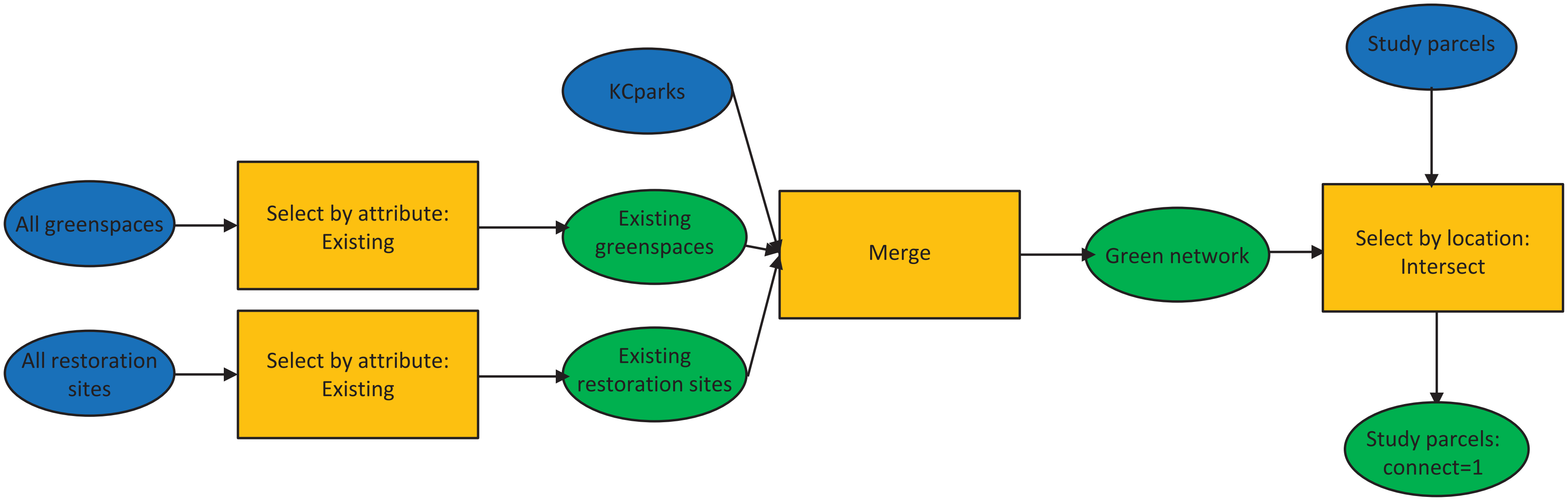
Input data:

study_parcels.shp

Restoration_projects.shp

Connectivity

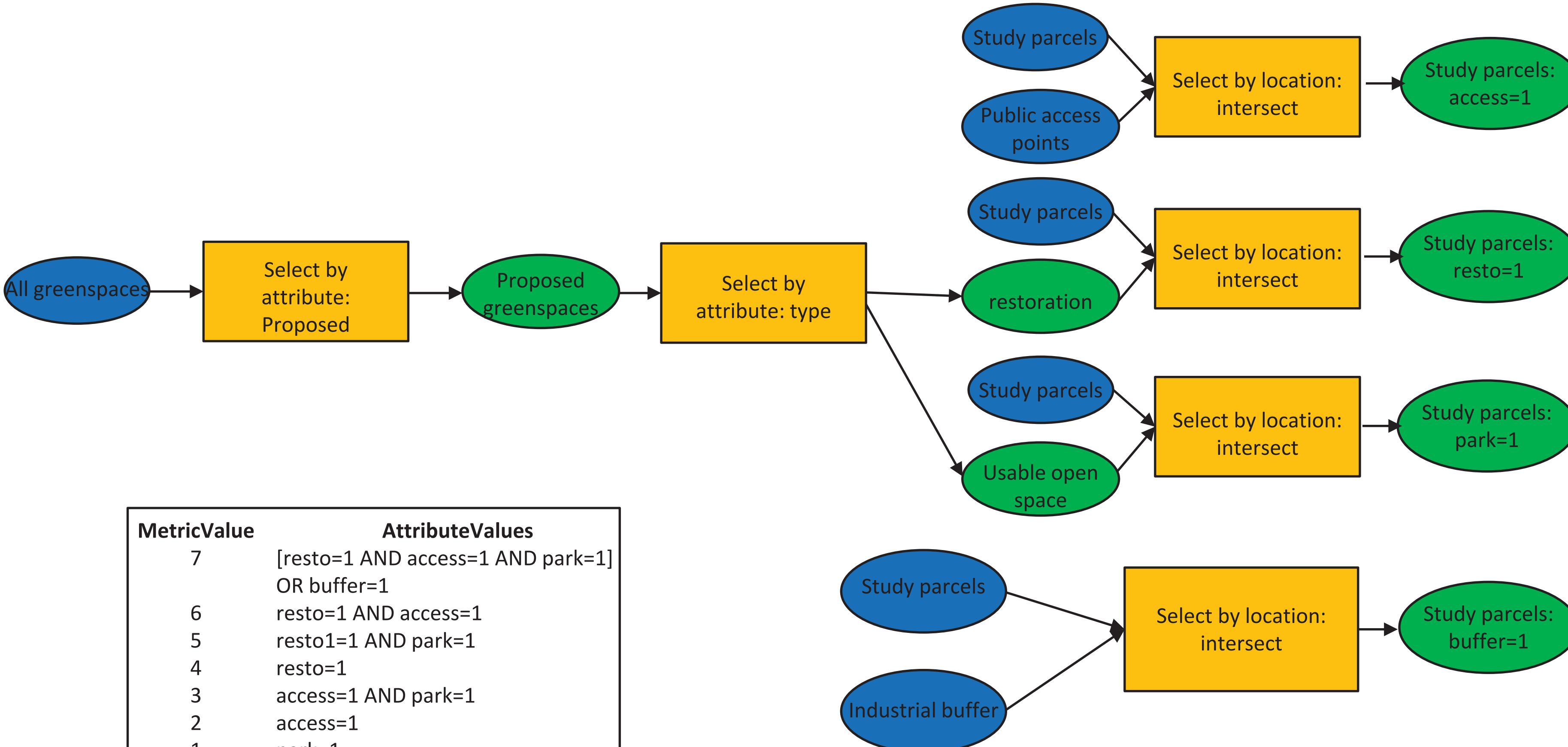
Social



Input data:
study_parcels.shp
Restoration_projects.shp
Greenspaces.shp
Kcparks.shp

Community Priority

Social

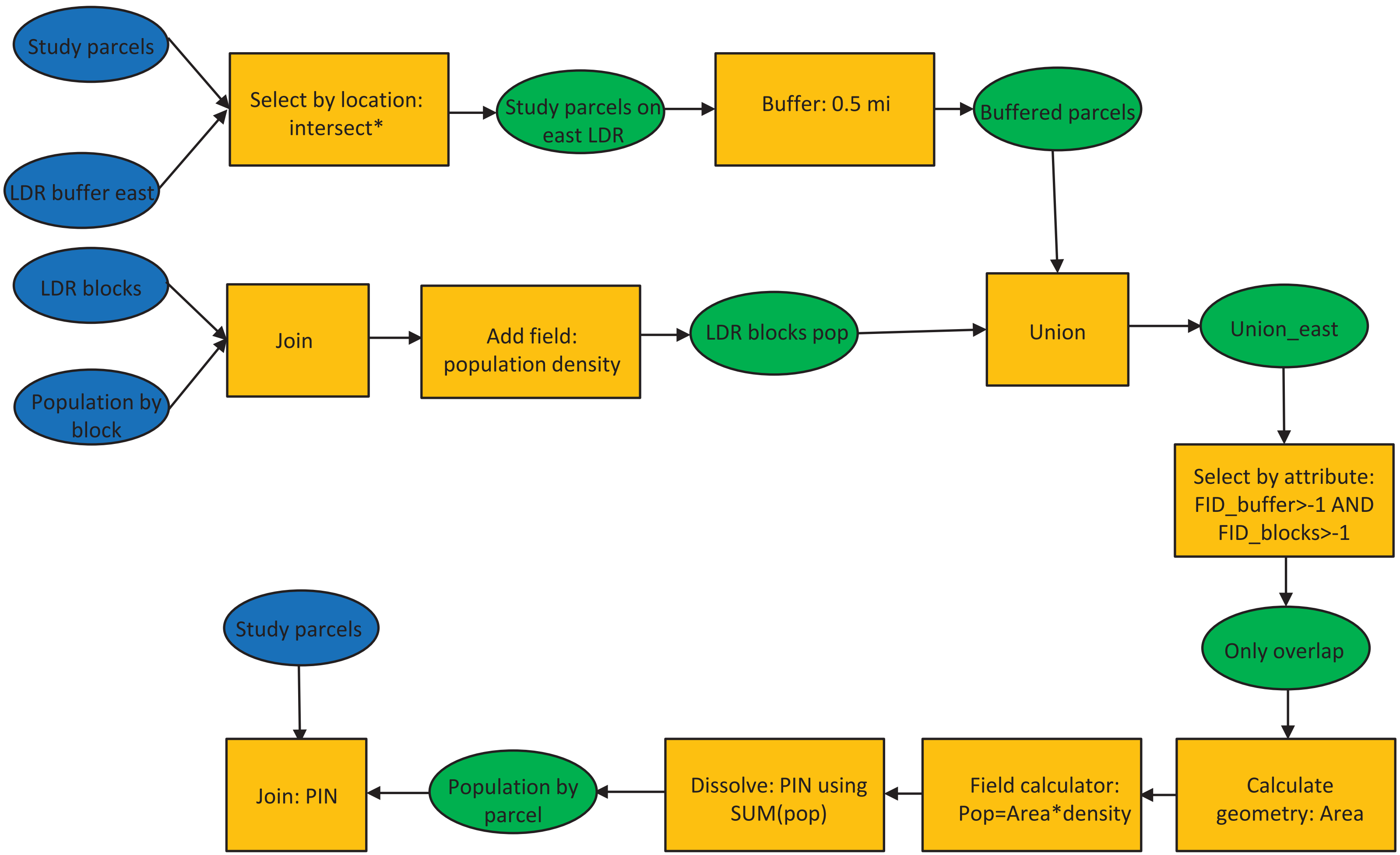


MetricValue	AttributeValues
7	[resto=1 AND access=1 AND park=1] OR buffer=1
6	resto=1 AND access=1
5	resto1=1 AND park=1
4	resto=1
3	access=1 AND park=1
2	access=1
1	park=1
0	none

Input data:
study_parcels.shp
Greenspaces.shp
Public_Access.shp
MIC.shp

Serviceable Population

Social

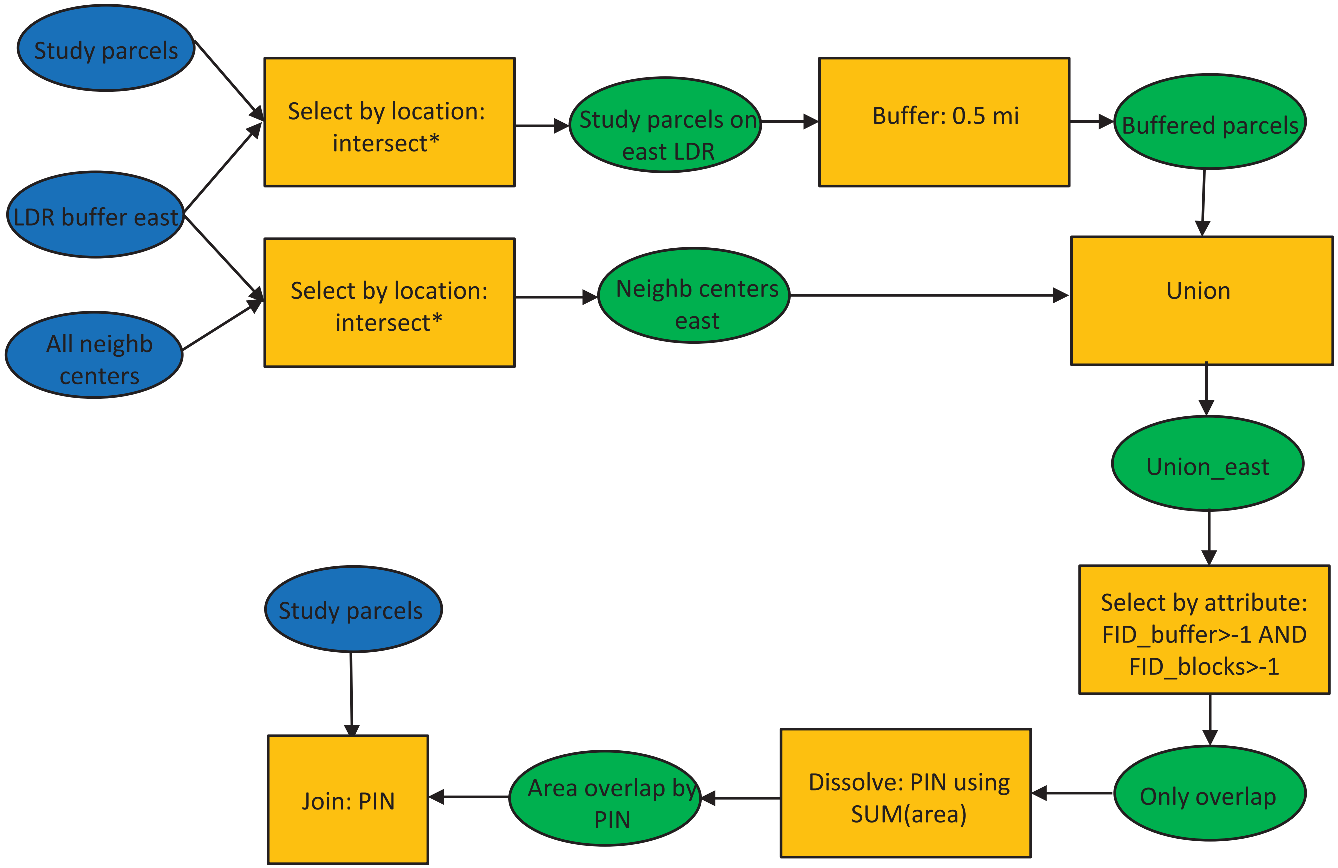


<u>Input data:</u>

study_parcels.shp
LDR_blocks2010.shp
KCblocks.dbf
LDRbuffer.shp

*Functions repeated for east and west halves of the LDR

Proximity
Social

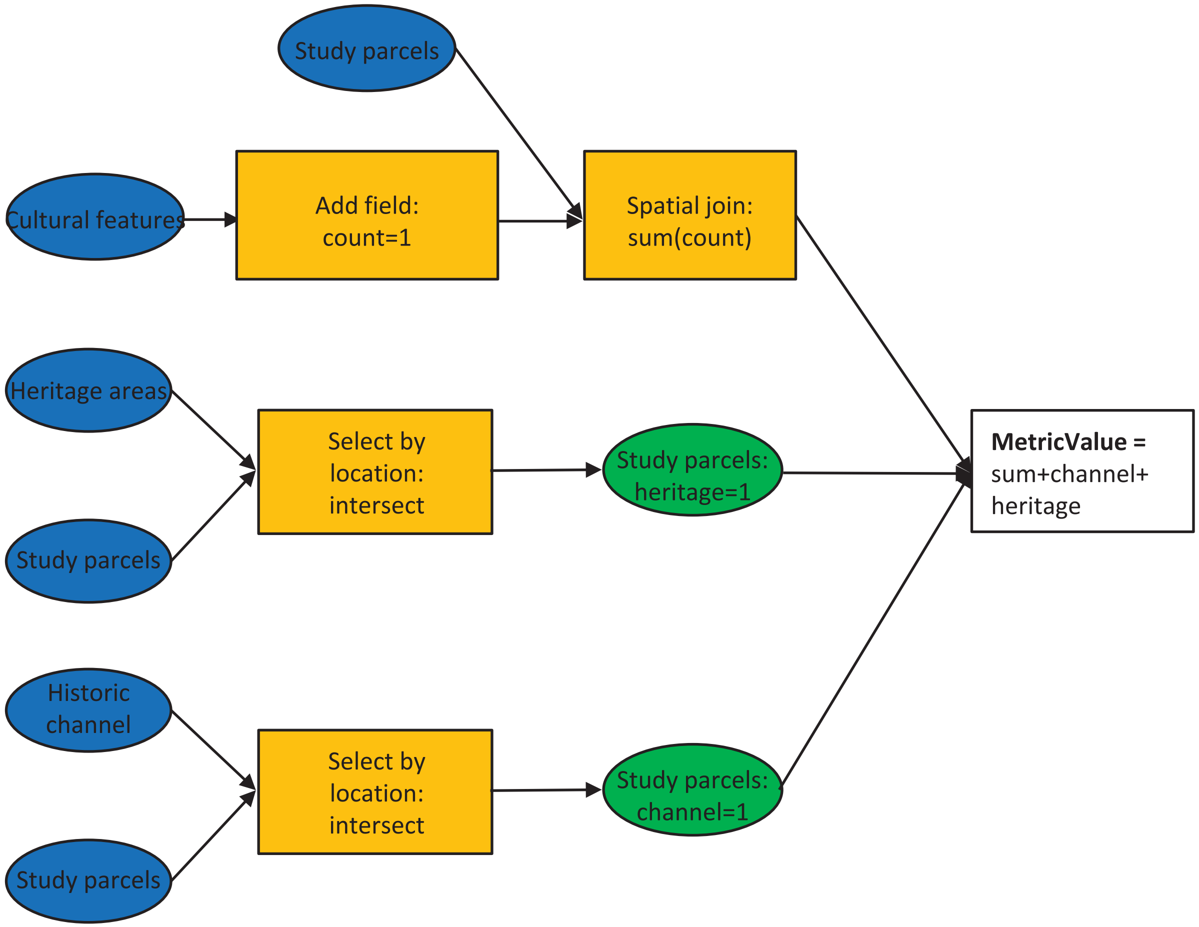


<u>Input data:</u>
study_parcels.shp
Neighb_centers.shp
LDRbuffer.shp

*Functions repeated for east and west halves of the LDR

Cultural Value

Social

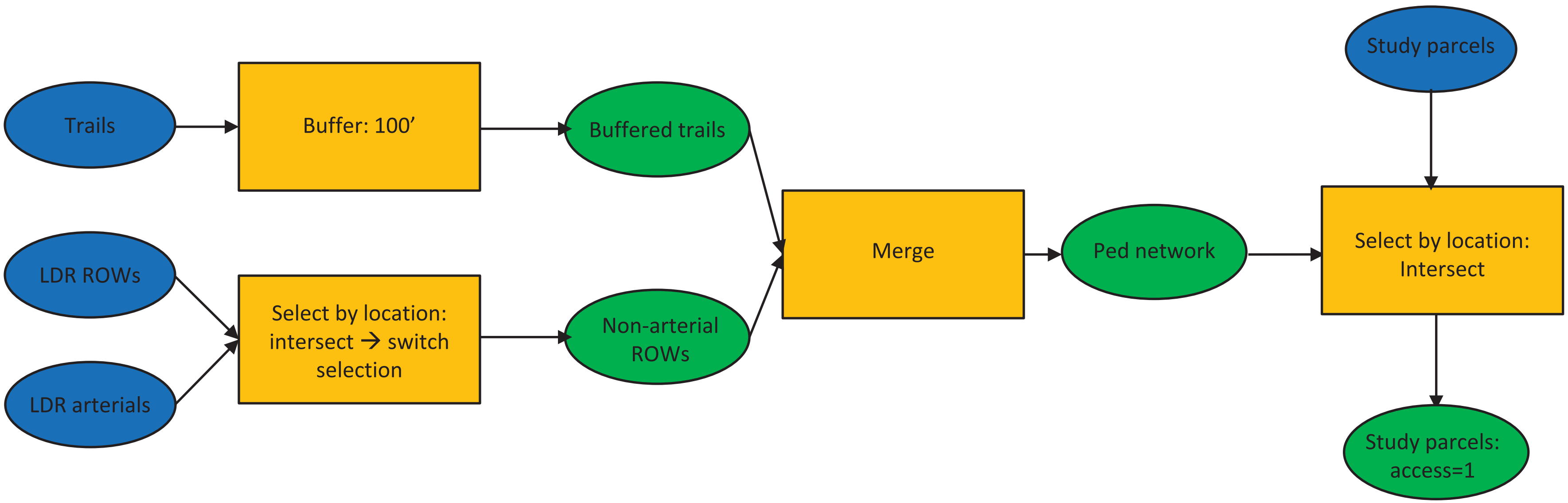


<u>Input data:</u>

study_parcels.shp
Cultural_value.shp
Native_heritage_areas.shp
Historic_channel.shp

Accessibility

Social



<u>Input data:</u>

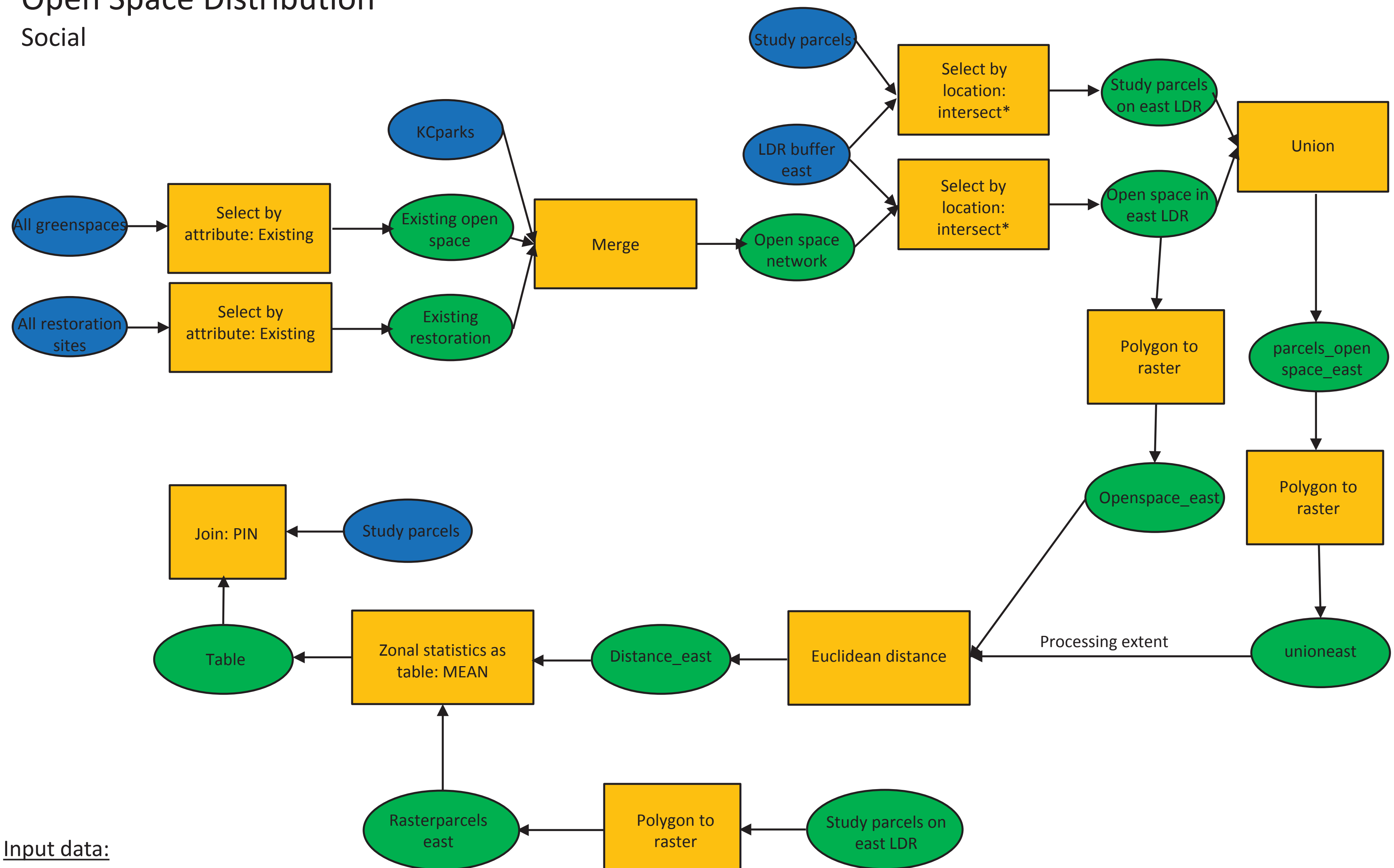
study_parcels.shp

trails.shp

LDRrow.shp

LDRarterials.shp

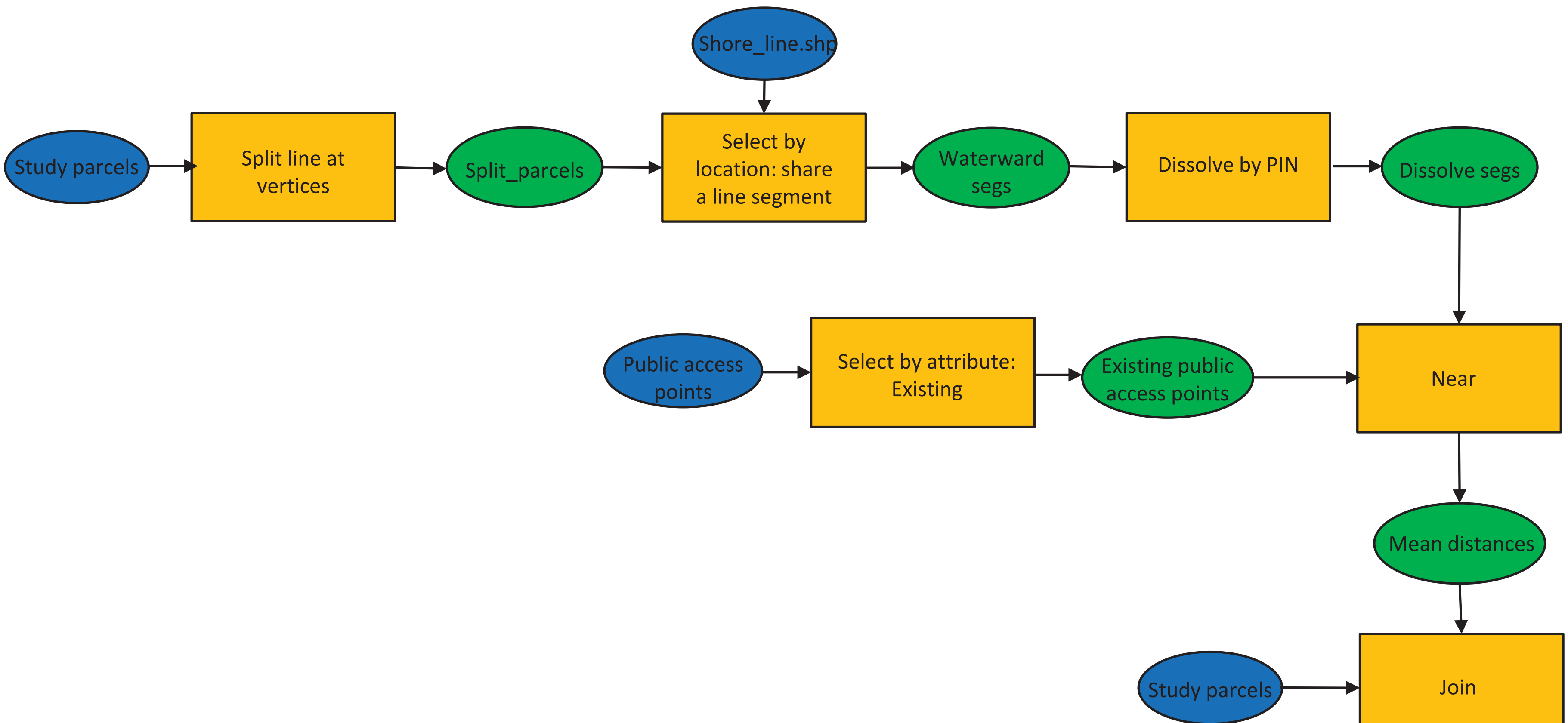
Open Space Distribution
Social



Input data:
study_parcels.shp
Restoration_projects.shp
Greenspaces.shp
KCparks.shp
LDRbuffer.shp

*Functions repeated for east and west halves of the LDR

Public Access Distribution
Social



Input data:
study_parcels.shp
shore_line.shp
Public_Access.shp

Digital input data

Filename	Data type	Description	Source	Usage
trail.shp	polyline	Trails in King County	King County GIS Center	Accessibility
row.shp	polygon	Road rights-of-way in King County	King County GIS Center	Accessibility
parcel.shp	polygon	Parcels in King County	King County GIS Center	All - study area delineation
wtrcrs.shp	polyline	Rivers and streams in King County	King County GIS Center	Green Features
park_kc.shp	polygon	Parks in King County	King County GIS Center	Open Space Distribution; Connectivity
zoning.shp	polygon	Zoning in unincorporated King County	King County GIS Center	Proximity
Affordable housing.shp	polygon	Proposed affordable housing areas	Michele Savelle, from DRCC Valley Vision Report	Community Priority
basic services.shp	polygon	Proposed areas for basic service centers	Michele Savelle, from DRCC Valley Vision Report	Community Priority
daylight creek.shp	polyline	Proposed stretches of daylighted creek	Michele Savelle, from DRCC Valley Vision Report	Community Priority
farm.shp	polygon	Proposed farm	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Green Industry.shp	polygon	Proposed areas of green industry	Michele Savelle, from DRCC Valley Vision Report	Community Priority
green st.shp	polyline	Proposed areas for green streets	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Greenbelt connection.shp	polygon	Proposed greenbelt connection	Michele Savelle, from DRCC Valley Vision Report	Community Priority
habitat-wetland restoration.shp	polygon	Proposed wetland habitat restoration site	Michele Savelle, from DRCC Valley Vision Report	Community Priority
industrial preservation.shp	polygon	Proposed area for industrial preservation	Michele Savelle, from DRCC Valley Vision Report	Community Priority
live-work spaces.shp	polygon	Proposed live-work areas	Michele Savelle, from DRCC Valley Vision Report	Community Priority
mixed use.shp	polygon	Proposed mix use areas	Michele Savelle, from DRCC Valley Vision Report	Community Priority
open space.shp	polygon	Proposed open space areas	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Park.shp	polygon	Proposed parks	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Proposed-trails.shp	polyline	Proposed trails	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Public shoreline access.shp	polygon	Proposed public shoreline access points	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Retail_district.shp	polygon	Proposed retail district	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Small retail.shp	polygon	Proposed small retail district	Michele Savelle, from DRCC Valley Vision Report	Community Priority
urban village.shp	polygon	Proposed or existing urban village	Michele Savelle, from DRCC Valley Vision Report	Community Priority
Historical river.shp	polygon	Historical Duwamish River channel	Michele Savelle, from DRCC Valley Vision Report	Cultural Value
native heritage areas.shp	polygon	Existing First Nations heritage areas	Michele Savelle, from DRCC Valley Vision Report	Cultural Value
Restoration site.shp	polygon	Existing restoration sites	Michele Savelle, from DRCC Valley Vision Report	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
SEP_LDWRI_River_Mile_Marks.shp	polyline	River mile markers for the Lower Duwamish River	Port of Seattle GIS	All - study area delineation
SEP_POS_Harbor_Lines	polyline	Administrative boundaries in the Lower Duwamish Waterway	Port of Seattle GIS	All - study area delineation
SEP_POS_Habitat_Sites	polygon	Existing shoreline habitat on Port of Seattle properties	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
DTB3_hub.shp	polygon	Existing habitat at Turning Basin 3	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
SouthPark_HEA_Restored.shp	polygon	Existing habitat at South Portland St and South Riverside Drive in South Park	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T104_HEA_Restored.shp	polygon	Existing habitat at Terminal 104	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T105_HEA_Restored.shp	polygon	Existing habitat at Terminal 105	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T107_hub.shp	polygon	Existing habitat at Terminal 107 and Kellogg Island	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T108_HEA_Restored.shp	polygon	Existing habitat at Terminal 108	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T115_HEA_Restored.shp	polygon	Existing habitat at Terminal 115	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T18_HEA_Restored.shp	polygon	Existing habitat at Terminal 18	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity

T25_HEA_Restored.shp	polygon	Existing habitat at Terminal 25 SW	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T5N_HEA_Restored.shp	polygon	Existing habitat at Terminal 5 N	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
T5SE_HEA_Restored.shp	polygon	Existing habitat at Terminal 5 SE	Port of Seattle GIS	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
SEP_POS_Public_Access_Areas	polygon	Public access sites owned by the Port of Seattle	Port of Seattle GIS	Public Access Distribution
fd_armoring.shp	polyline	Extent and degree of shoreline armoring in Puget Sound	PSNERP Change Analysis Database	Brown Features
fd_OWS.shp	polygon	Overwater cover structures in Puget Sound	PSNERP Change Analysis Database	Brown Features
fd_impervious_T3.shp	polygon	Percent of impervious surface cover in Puget Sound	PSNERP Change Analysis Database	Brown Features
tl_2010_53033_tabblock10.shp	polygon	Census blocks in King County	US Census	Population
DEC_10_SF1_QTP5.csv	table	Population by census block in King County	US Census	Population
Riparian Corridors.shp	polygon	Designated Critical Areas in Washington State - Riparian Corridors	WA Department of Ecology	Green Features
Wetlands.shp	polygon	Designated Critical Areas in Washington State - Wetlands	WA Department of Ecology	Green Features
arterial.shp	polyline	Arterial roads in King County	WAGDA	Accessibility
cenvill.shp	polygon	Urban Village boundaries	WAGDA	Proximity
shoreline.shp	polygon	Shorelines in King County	WAGDA	Size

Digitized files

Description	Datatype	Source	Usage
Existing trails	polyline	Delridge Neighborhood Plan	Accessibility
Proposed public access sites	point	Delridge Neighborhood Plan	Community Priority
Proposed greenspace conservancies	polygon	Delridge Neighborhood Plan	Community Priority
Areas of historical significance	point	Delridge Neighborhood Plan	Cultural Value
Existing creeks and creek buffers	polygon	Delridge Neighborhood Plan	Green Features; Open Space Distribution; Connectivity
Existing parks and public facilities, including community gardens	point, polygon	Delridge Neighborhood Plan	Open Space Distribution; Connectivity
Delridge neighborhood boundary	polygon	Delridge Neighborhood Plan	Proximity
Proposed "concentrated nodes of activity"	polygon	Delridge Neighborhood Plan	Proximity
Existing and proposed public access points, boat launches, public use street ends	point	DRCC Valley Vision Map	Community Priority; Public Access Distribution
Existing and proposed shoreline street end access points	point	DRCC Valley Vision Map	Community Priority; Public Access Distribution
Existing and proposed cultural amenities: tribal art, museum, cultural/historical site, public art site	point	DRCC Valley Vision Map	Cultural Value
Proposed new open spaces	polygon	Georgetown Neighborhood Plan	Community Priority
Historic sites and buildings	point	Georgetown Neighborhood Plan	Cultural Value
Existing open space/recreation spaces	polygon	Georgetown Neighborhood Plan	Open Space Distribution; Connectivity
Georgetown neighborhood boundary and neighborhood anchor	polygon	Georgetown Neighborhood Plan	Proximity
Seattle Design District boundary	polygon	Georgetown Neighborhood Plan	Proximity
Public access gaps and opportunities	point	King County SMP	Community Priority
Habitat Focus Area boundaries	polygon	NRDA PEIS	Scientific Priority
Existing and proposed shoreline street end access points	point	SDOT Shoreline Ends Program	Community Priority; Public Access Distribution
Proposed parks in Seattle	polygon	Seattle CIP	Community Priority
Gaps in usable open space in Seattle	polygon	Seattle Open Space Plan	Community Priority
Existing open space in Seattle	polygon	Seattle Open Space Plan	Open Space Distribution; Connectivity
Proposed and existing habitat restoration projects (Table 16)	polygon	Seattle SMP	Scientific Priority; Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
Proposed parks	polygon	South Park Neighborhood Plan	Community Priority
South Park neighborhood boundary	polygon	South Park Neighborhood Plan	Proximity
Desired area for annexation into the residential urban village	polygon	South Park Neighborhood Plan	Proximity
Proposed parks and access points in Tukwila	polygon, point	Tukwila CIP	Community Priority
Park plan exhibits	polygon	Tukwila Open Space Plan	Community Priority
Existing and proposed conservancies	polygon	Tukwila Open Space Plan	Community Priority; Open Space Distribution; Connectivity
Existing and proposed waterfront access sites	point	Tukwila Open Space Plan	Community Priority; Public Access Distribution
Existing and proposed water trail sites	point	Tukwila Open Space Plan	Community Priority; Public Access Distribution

Existing and proposed interpretive exhibits	point	Tukwila Open Space Plan	Cultural Value
Existing and proposed historical sites	point	Tukwila Open Space Plan	Cultural Value
Existing and proposed parks, golf courses, open spaces, and trails	polygon, polyline	Tukwila SMP	Community Priority; Open Space Distribution; Connectivity
Historic sites	point	Tukwila SMP	Cultural Value
Sensitive areas in the shoreline jurisdiction	polygon	Tukwila SMP	Green Features
Completed restoration projects in Tukwila	polygon	Tukwila SMP	Habitat Distribution; Adjacency; Open Space Distribution; Connectivity
Existing public access points and trails	point, polyline	Tukwila SMP	Public Access Distribution; Accessibility
Proposed habitat restoration projects and river stretches	polygon	Tukwila SMP	Scientific Priority
Proposed habitat restoration projects and river stretches	polygon	WRIA 9	Scientific Priority

Appendix C
Parcel results

Code	Metric name
E1	Scientific priority
E2	Adjacency
E3	Habitat distribution
E4	Size
E5	Green features
E6	Brown features
S1	Community priority
S2	Population
S3	Proximity
S4	Cultural value
S5	Accessibility
S6	Open space distribution
S7	Public access distribution
S8	Connectivity

PIN	E1	E2	E3	E4	E5	E6	EcoIndex	S1	S2	S3	S4	S5	S6	S7	S8	SocialIndex
0001400003	1	1	4	3	1	3	1.85	1	5	5	2	1	2	3	1	2.6
0001400005	1	1	4	3	1	2	1.7	1	5	5	2	1	2	2	1	2.4
0001600001	1	5	1	2	1	4	2.3	1	5	5	1	5	2	1	5	2.7
0001600014	1	1	4	1	1	2	1.6	1	1	1	2	1	5	5	1	2.3
0001600020	2	1	3	3	1	3	1.9	3	1	1	1	1	5	4	1	2.4
0001600023	2	1	3	2	1	3	1.85	3	1	1	1	1	5	4	1	2.4
0001600029	1	1	2	1	2	2	1.55	1	4	4	1	5	3	1	1	2.35
0001600044	1	5	1	2	1	1	1.85	5	4	4	1	5	1	1	5	3.15
0001600060	2	5	1	3	2	4	2.8	5	4	4	2	5	2	3	5	3.75
0001600061	2	1	2	3	2	4	2.15	3	3	3	3	1	3	3	1	2.7
0001600062	1	1	1	1	3	3	1.8	3	3	3	1	5	3	1	1	2.5
0001800091	5	1	3	2	2	3	2.7	3	2	3	2	5	5	3	1	3.1
0001800104	2	1	2	3	2	4	2.15	1	2	3	2	5	4	2	1	2.4
0001800113	5	1	3	2	1	3	2.45	3	2	3	2	5	5	2	1	2.9
0001800128	5	1	2	2	1	4	2.45	1	2	3	2	5	4	2	1	2.4
0002800033	1	1	5	1	1	2	1.75	3	4	5	1	5	2	1	1	2.8
0003000039	4	1	4	1	1	2	2.2	1	3	4	1	5	1	4	5	2.85
0003000044	1	1	3	1	1	2	1.45	1	3	4	1	1	1	4	5	2.45
0003000049	4	1	4	5	1	3	2.55	1	4	5	4	5	1	4	5	3.4
0003000053	1	1	3	1	1	1	1.3	1	3	4	1	5	2	4	5	2.95
0003000115	1	1	3	2	1	2	1.5	1	3	4	1	5	2	1	5	2.35
0003400018	4	5	2	4	1	4	3.15	3	1	1	3	5	4	1	1	2.3
0003400019	1	1	2	1	1	3	1.45	3	3	3	2	1	4	3	1	2.7
0003400026	1	1	3	1	1	2	1.45	3	1	1	1	5	5	1	1	2.2
0003400048	1	1	3	1	1	2	1.45	3	1	1	1	5	5	1	1	2.2
0003800002	1	1	2	1	3	2	1.8	1	5	5	1	5	3	1	1	2.6
0003800003	1	1	2	2	3	3	2	1	5	5	2	5	3	2	5	3.1
0004800002	4	1	2	3	3	2	2.5	1	4	5	3	5	4	1	1	2.8
0004800003	4	1	2	3	2	2	2.25	1	3	4	2	5	3	1	1	2.35
0004800010	4	1	2	2	1	3	2.1	1	2	3	2	5	3	3	1	2.5

0004800013	4	1	2	3	1	2	2	1	2	3	2	5	4	3	1	2.6
0004800016	4	1	2	1	1	1	1.75	1	1	1	2	5	4	4	1	2.4
0004800019	4	1	2	1	1	2	1.9	1	1	1	2	5	4	1	1	1.8
0007400033	2	1	3	2	1	3	1.85	1	1	1	2	1	5	4	1	2.1
0022000005	5	5	1	4	2	3	3.3	3	1	2	2	5	2	1	5	2.35
0179000005	1	1	3	1	1	1	1.3	1	3	4	1	5	3	2	1	2.45
0179000020	1	1	3	1	1	1	1.3	1	3	4	1	5	3	2	1	2.45
0179000025	1	1	3	1	1	1	1.3	1	3	4	1	5	3	2	1	2.45
0179000030	1	1	3	1	1	1	1.3	1	3	4	1	5	3	2	1	2.45
0179000040	1	1	3	1	1	2	1.45	1	3	4	1	5	2	2	1	2.35
0179000060	1	1	3	1	1	1	1.3	1	3	4	1	5	2	2	1	2.35
0179000070	1	1	3	1	1	1	1.3	1	3	4	1	5	2	2	1	2.35
0179000080	1	1	3	1	1	1	1.3	1	3	4	1	5	2	2	1	2.35
0179000090	1	1	3	1	1	2	1.45	1	3	4	1	5	2	2	1	2.35
0179000100	1	1	3	1	1	1	1.3	1	3	4	1	5	1	2	1	2.25
0179002700	1	1	2	1	1	1	1.15	1	3	4	2	5	1	2	5	2.55
0179002715	1	1	2	1	1	1	1.15	1	3	4	2	5	1	2	1	2.35
0179002735	1	1	2	1	1	2	1.3	1	3	4	1	5	2	2	1	2.35
0179002736	1	1	2	1	1	2	1.3	1	3	4	1	5	2	2	1	2.35
0179002738	1	1	2	1	1	2	1.3	1	3	4	1	5	2	2	1	2.35
0179002740	1	1	2	1	1	2	1.3	1	3	4	1	5	2	2	1	2.35
0179002745	1	1	2	1	1	2	1.3	1	3	4	1	5	2	2	1	2.35
0179002750	1	1	2	1	1	2	1.3	1	3	4	1	5	2	2	1	2.35
0179002755	1	1	2	1	1	2	1.3	1	3	4	1	5	3	2	1	2.45
0179002760	1	1	2	1	1	2	1.3	1	3	4	1	5	3	2	1	2.45
0179002762	1	1	2	1	1	2	1.3	1	3	4	1	5	3	2	1	2.45
0179002800	1	1	1	1	1	2	1.15	1	3	4	1	5	3	2	1	2.45
0179002820	1	1	1	1	1	2	1.15	1	4	4	1	5	3	2	1	2.55
0179002830	1	1	1	1	1	2	1.15	1	4	4	1	5	2	2	1	2.45
0179002840	1	1	1	1	1	2	1.15	1	4	4	1	5	2	2	1	2.45
0179002845	1	1	1	1	1	1	1	1	4	4	2	5	2	2	1	2.55
0179002860	1	1	1	1	1	1	1	1	4	5	1	5	2	2	1	2.6
0179002885	1	1	1	1	1	1	1	1	4	5	1	5	1	2	1	2.5
0179002890	1	5	1	1	1	1	1.8	1	4	5	1	5	1	2	5	2.7
0179002950	1	5	1	3	2	1	2.15	1	4	5	4	5	1	1	5	2.8
0179002952	1	5	1	2	2	2	2.25	1	4	5	1	5	1	1	5	2.5
0179003238	1	1	3	1	1	2	1.45	1	3	4	2	5	1	2	5	2.55
0179003239	1	1	3	3	1	2	1.55	1	3	4	3	5	1	1	5	2.45
0213000046	1	5	1	1	2	1	2.05	3	2	1	2	5	1	1	5	2.2
0423049001	1	5	1	2	1	2	2	2	4	3	2	1	2	3	5	2.6
0423049002	1	1	3	2	1	3	1.65	3	1	1	2	5	5	3	1	2.7
0423049011	1	1	3	1	1	2	1.45	1	1	1	2	1	5	3	1	1.9
0423049016	1	1	3	2	1	4	1.8	3	1	1	2	5	5	2	1	2.5
0423049047	4	1	3	1	1	2	2.05	3	1	1	1	1	5	3	1	2.2
0423049051	1	1	3	1	1	3	1.6	3	1	1	1	5	5	1	1	2.2
0423049057	1	5	1	2	1	2	2	3	5	2	3	5	2	1	5	2.85
0423049073	1	1	1	1	1	2	1.15	2	4	3	1	5	3	3	5	3

0423049082	1	1	1	1	1	3	1.3	3	1	1	2	1	2	3	1	2
0423049083	1	1	2	1	1	3	1.45	3	1	1	1	1	4	3	1	2.1
0423049114	1	5	1	1	1	1	1.8	3	1	1	2	1	1	3	5	2.1
0423049117	1	1	3	1	1	3	1.6	3	1	1	1	1	5	1	1	1.8
0423049118	1	5	1	2	2	1	2.1	3	1	1	4	5	1	3	5	2.7
0423049150	1	5	2	4	1	4	2.55	4	4	3	3	1	4	3	5	3.3
0423049153	1	1	1	1	1	3	1.3	3	1	1	2	1	2	3	1	2
0423049159	1	1	1	1	1	2	1.15	3	1	1	2	1	3	3	1	2.1
0423049163	1	5	1	1	1	3	2.1	3	1	1	2	1	1	3	5	2.1
0423049169	1	1	2	2	1	3	1.5	3	1	1	2	1	3	3	1	2.1
0423049176	1	1	1	1	1	3	1.3	3	1	1	2	1	2	3	1	2
0423049183	1	1	3	1	1	4	1.75	3	1	1	3	5	5	3	1	2.8
0423049187	1	5	1	2	1	1	1.85	2	4	4	2	5	1	3	5	3.05
0423049189	1	1	2	3	1	3	1.55	3	4	2	3	1	3	2	1	2.45
0423049195	1	1	3	1	1	4	1.75	3	2	2	2	1	5	3	1	2.55
0733000180	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
0733000190	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
0733000200	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
0733000205	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
0733000210	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
0733000220	1	1	4	1	1	1	1.45	1	1	2	3	5	1	4	1	2.35
0733000225	1	1	4	1	1	1	1.45	1	1	2	3	5	1	4	5	2.55
0923049066	4	1	3	2	4	3	3	1	5	2	3	5	4	3	1	2.85
0923049153	1	1	2	2	1	2	1.35	1	1	1	3	1	3	2	1	1.6
0923049155	1	1	1	3	1	3	1.4	3	1	1	4	5	2	3	5	2.8
0923049278	1	1	1	1	2	2	1.4	3	4	1	3	5	1	1	5	2.5
0923049292	1	1	2	1	1	1	1.15	1	1	1	3	1	4	2	1	1.7
1023049002	1	1	2	1	1	1	1.15	1	1	2	3	5	2	1	1	1.85
1023049009	1	1	3	2	1	2	1.5	1	4	4	3	5	2	1	5	2.65
1023049011	1	1	3	2	1	3	1.65	1	4	2	2	5	4	3	1	2.65
1023049012	1	1	3	1	1	3	1.6	1	3	2	2	5	3	3	1	2.45
1023049045	1	1	3	1	1	1	1.3	1	1	2	3	5	1	4	5	2.55
1023049055	4	1	2	1	1	1	1.75	1	1	2	3	1	2	1	1	1.45
1023049057	4	1	3	2	1	1	1.95	2	2	2	4	5	1	1	5	2.35
1023049059	1	1	2	2	1	2	1.35	1	1	2	3	1	3	2	1	1.75
1023049060	4	1	2	1	1	1	1.75	1	1	2	2	1	3	1	1	1.45
1023049061	1	1	2	1	1	1	1.15	1	1	2	2	5	1	1	1	1.65
1023049063	4	1	3	1	1	1	1.9	1	2	2	3	5	1	2	1	2.05
1023049064	1	1	4	1	1	1	1.45	1	2	3	2	5	3	3	1	2.5
1023049071	4	1	2	2	1	1	1.8	1	1	2	4	1	3	1	1	1.65
1023049072	4	1	3	1	1	2	2.05	1	2	2	2	5	1	1	5	1.95
1023049076	1	1	3	1	1	3	1.6	1	2	2	2	5	2	3	1	2.25
1023049083	1	1	2	1	1	1	1.15	1	1	1	3	1	4	2	1	1.7
1023049085	1	1	3	1	1	2	1.45	1	1	2	2	5	1	1	5	1.85
1423049041	1	1	3	3	2	3	1.95	1	5	5	1	5	2	1	1	2.5
1423049043	4	1	5	3	2	3	2.85	1	5	3	2	1	1	2	5	2.2
1722802315	1	1	3	1	1	3	1.6	1	1	3	2	5	5	1	1	2.2

1824049018	1	5	1	1	1	2	1.95	1	2	1	3	1	1	1	5	1.5
1924049002	4	1	3	3	1	3	2.3	3	1	2	2	5	5	1	1	2.45
1924049003	1	5	3	4	1	4	2.7	4	2	1	2	5	3	3	5	3
1924049026	1	1	4	2	1	4	1.95	1	2	1	1	5	3	4	1	2.3
1924049028	1	1	4	2	1	4	1.95	3	2	1	2	5	4	4	1	2.9
1924049029	1	1	4	3	3	3	2.35	4	2	1	2	5	3	4	1	3
1924049041	1	1	2	2	1	4	1.65	2	1	1	2	1	4	3	1	2
1924049043	1	1	3	2	1	4	1.8	1	1	2	2	5	5	2	1	2.25
1924049051	1	1	2	2	1	3	1.5	1	1	2	2	5	4	3	1	2.35
1924049052	1	1	2	1	1	4	1.6	1	1	2	2	5	4	3	1	2.35
1924049067	1	1	2	3	2	4	1.95	1	1	1	2	1	3	2	1	1.5
1924049070	1	1	2	2	1	4	1.65	1	1	2	3	1	4	3	1	2.05
1924049075	1	1	2	4	2	4	2	3	1	3	2	1	4	2	1	2.3
1924049092	4	1	3	3	1	4	2.45	4	1	3	1	5	5	1	1	2.7
1924049103	5	5	1	5	4	2	3.7	3	3	1	4	5	2	1	5	2.6
1924049104	2	5	1	3	1	1	2.1	1	2	1	3	1	1	1	5	1.5
2136200641	2	5	1	3	2	4	2.8	4	2	2	2	5	2	1	5	2.65
2136200666	5	5	1	1	1	3	2.9	3	1	1	1	5	1	1	5	2
2136200670	5	5	1	2	1	3	2.95	3	2	2	1	5	2	2	5	2.55
2136200681	5	1	1	2	1	3	2.15	3	2	2	2	5	3	2	1	2.55
2136200706	2	1	2	3	2	4	2.15	3	2	2	2	5	4	3	1	2.85
2137000060	1	1	3	1	1	1	1.3	1	4	5	1	5	1	1	1	2.3
2137000070	1	1	3	1	1	1	1.3	1	4	4	1	1	1	1	5	1.95
2172000005	1	1	2	1	1	2	1.3	1	4	5	2	5	3	2	1	2.8
2172000020	1	1	2	1	1	1	1.15	1	4	5	1	5	3	2	1	2.7
2172000025	1	1	2	1	1	1	1.15	1	4	4	1	5	3	2	1	2.55
2172000030	1	1	2	1	1	1	1.15	1	4	4	1	5	3	2	1	2.55
2172000035	1	1	2	1	1	1	1.15	1	4	4	1	5	3	2	1	2.55
2172000040	1	1	2	1	1	1	1.15	1	3	4	1	5	3	2	1	2.45
2172000045	1	1	2	1	1	1	1.15	1	3	4	1	5	3	2	1	2.45
2172000050	1	1	2	1	1	1	1.15	1	3	4	1	5	3	1	1	2.25
2172000051	1	1	2	1	1	1	1.15	1	3	4	1	5	3	2	1	2.45
2172000060	1	1	2	1	1	1	1.15	1	3	4	1	5	3	2	1	2.45
2172000070	1	1	2	1	1	1	1.15	1	3	4	2	5	3	2	1	2.55
2172000075	1	1	2	1	1	1	1.15	1	3	4	2	5	3	2	1	2.55
2172000080	1	1	2	1	1	1	1.15	1	3	4	2	5	3	2	1	2.55
2172000095	1	1	2	1	1	1	1.15	1	3	4	2	5	3	2	1	2.55
2172000105	1	1	3	1	1	1	1.3	1	2	3	2	5	3	2	1	2.3
2172000110	1	1	3	1	1	1	1.3	1	2	3	2	5	3	2	1	2.3
2172000115	1	1	3	1	1	1	1.3	1	2	3	2	5	3	2	1	2.3
2172000120	1	1	3	1	1	1	1.3	1	2	3	2	5	3	2	1	2.3
2172000126	1	1	3	1	1	1	1.3	1	2	3	2	5	3	2	1	2.3
2172000130	1	1	3	1	1	1	1.3	1	2	3	2	5	3	2	1	2.3
2172000140	1	1	3	1	1	1	1.3	1	2	3	2	5	3	2	1	2.3
2172000145	1	1	3	1	1	1	1.3	1	2	3	2	5	2	2	1	2.2
2172000150	1	1	3	1	1	1	1.3	1	2	3	2	5	2	2	1	2.2
2172000155	1	1	3	1	1	1	1.3	1	2	3	2	5	2	2	1	2.2

2172000160	1	1	3	2	1	1	1.35	1	1	3	2	5	2	2	1	2.1
2172000165	1	1	3	1	1	1	1.3	1	2	3	2	5	2	2	1	2.2
2172000175	1	1	3	1	1	1	1.3	1	2	3	1	5	2	2	1	2.1
2172000180	1	1	3	1	1	1	1.3	1	2	3	1	5	2	2	1	2.1
2172000185	1	1	3	1	1	1	1.3	1	2	3	1	5	2	2	1	2.1
2172000190	1	1	3	1	1	1	1.3	1	2	3	1	5	2	2	1	2.1
2172000195	1	1	3	1	1	1	1.3	1	2	3	1	5	2	1	1	1.9
2172000205	1	1	3	1	1	1	1.3	1	2	3	1	5	2	1	1	1.9
2172000210	1	1	3	1	1	1	1.3	1	2	3	1	5	1	1	1	1.8
2172000215	1	1	3	1	1	1	1.3	2	3	3	1	5	1	1	5	2.3
2172000225	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	5	2.25
2172000232	1	1	3	1	1	1	1.3	1	3	3	1	5	1	1	5	2.1
2172000233	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	5	2.25
2172000330	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	5	2.25
2172000335	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	1	2.05
2172000340	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	1	2.05
2172000385	1	1	3	1	1	1	1.3	3	4	4	2	1	1	2	1	2.45
2172000420	1	1	2	1	1	2	1.3	1	4	5	1	1	3	2	1	2.3
2185000005	2	5	1	3	1	3	2.4	5	1	1	3	1	1	3	5	2.6
2185000475	4	1	2	1	1	3	2.05	3	5	5	1	5	3	2	1	3.2
2185000495	4	1	1	1	1	2	1.75	3	5	5	1	5	3	2	1	3.2
2185000505	4	1	1	1	1	2	1.75	3	5	5	1	5	3	2	1	3.2
2185000520	1	1	1	1	1	2	1.15	3	5	5	1	5	3	2	1	3.2
2185000610	1	1	1	1	1	1	1	3	5	5	1	5	2	1	1	2.9
2185000685	4	1	2	1	1	2	1.9	3	5	5	1	5	4	2	1	3.3
2185000695	4	1	2	1	1	2	1.9	3	5	5	1	5	4	2	1	3.3
2185000815	4	1	2	1	1	2	1.9	3	5	5	1	5	3	1	1	3
2185000825	4	1	2	1	1	3	2.05	3	5	5	1	5	4	2	1	3.3
2185000860	4	1	2	1	1	3	2.05	3	5	5	1	5	3	1	1	3
2185000895	4	1	2	1	1	3	2.05	3	5	5	1	5	4	1	1	3.1
2185000915	4	1	2	1	1	2	1.9	1	5	5	1	5	4	1	1	2.7
2185000925	4	1	2	1	1	1	1.75	1	5	5	1	5	4	1	1	2.7
2185000970	4	1	2	1	1	1	1.75	1	5	5	1	5	4	1	1	2.7
2185000990	4	1	2	1	1	2	1.9	3	5	5	1	5	4	1	1	3.1
2185000995	4	1	2	1	1	2	1.9	3	5	5	1	5	4	1	1	3.1
2185600025	1	1	1	1	1	3	1.3	1	5	5	1	5	3	1	1	2.6
2185600070	1	1	2	1	1	3	1.45	1	5	5	1	5	3	1	1	2.6
2323049001	4	1	5	2	2	2	2.65	1	3	1	5	5	1	1	5	2.2
232304UNKN	1	1	5	1	1	1	1.6	1	3	1	1	1	1	2	1	1.4
2716000030	4	1	2	1	3	2	2.4	1	3	4	1	5	4	1	1	2.35
2716000070	4	5	1	2	1	2	2.6	1	1	2	2	5	2	2	5	2.15
2716000075	4	5	1	2	1	3	2.75	1	1	2	2	5	2	3	5	2.35
2840201095	2	5	1	1	1	1	2	1	2	1	3	1	1	1	5	1.5
2840201235	1	5	1	1	2	1	2.05	3	3	1	1	5	1	1	5	2.2
2843800005	1	5	1	2	2	1	2.1	3	5	2	4	5	1	1	5	2.85
284380PUBL	1	5	1	1	1	1	1.8	1	4	1	3	5	1	1	5	2.1
2924049030	2	5	1	2	1	3	2.35	3	1	1	2	5	2	1	5	2.2

2924049043	2	5	1	2	1	3	2.35	3	2	2	2	5	2	2	5	2.65
2924049083	2	1	2	2	2	4	2.1	1	2	3	2	5	3	1	1	2.1
2924049089	2	1	2	2	1	4	1.85	3	2	2	2	5	4	2	1	2.65
2924049090	5	5	1	2	2	4	3.35	4	1	1	2	5	2	1	5	2.4
2924049108	5	1	1	1	2	2	2.2	3	1	1	2	5	1	1	1	1.9
2924049110	2	5	1	3	2	3	2.65	3	2	2	2	1	1	2	5	2.15
302404PUBL	1	1	1	1	2	1	1.25	3	2	1	1	1	3	1	1	1.7
3224049002	1	1	1	1	1	2	1.15	3	5	5	1	5	1	1	1	2.8
3224049003	1	1	1	1	1	3	1.3	3	5	5	1	5	2	1	1	2.9
3224049004	1	1	1	1	1	2	1.15	3	5	5	1	5	2	1	1	2.9
3224049037	1	1	1	1	1	3	1.3	3	5	5	1	5	2	1	1	2.9
3324049002	2	1	2	2	1	3	1.7	5	1	1	2	1	4	3	1	2.6
3347400005	1	1	4	1	1	2	1.6	1	3	3	1	5	3	1	1	2.1
3347400070	1	1	4	1	1	1	1.45	1	3	3	1	5	2	1	1	2
3347400135	1	1	4	1	1	1	1.45	1	3	3	1	5	2	1	1	2
3347400140	1	1	4	1	1	1	1.45	1	3	3	1	5	2	1	1	2
3347400145	1	1	4	1	1	1	1.45	1	3	3	1	5	1	1	1	1.9
3347400160	1	1	4	1	1	1	1.45	1	3	4	1	5	1	1	5	2.25
3347400168	1	1	4	1	1	1	1.45	1	3	4	1	5	1	1	5	2.25
3347400175	1	1	4	1	1	2	1.6	1	3	4	2	5	1	1	5	2.35
3347400180	1	1	4	1	1	1	1.45	1	3	4	1	5	1	1	5	2.25
3347400185	1	1	4	1	1	1	1.45	1	3	4	1	5	1	1	5	2.25
3347400190	1	1	4	1	1	1	1.45	1	3	4	2	5	1	1	5	2.35
3347400200	1	1	4	1	1	1	1.45	1	3	4	1	5	1	1	1	2.05
3347400210	1	1	4	1	1	1	1.45	1	3	4	1	5	2	1	1	2.15
3347400215	1	1	4	1	1	1	1.45	1	3	4	1	5	2	1	1	2.15
3347400220	1	1	4	1	1	1	1.45	1	3	4	1	5	2	1	1	2.15
3347400225	1	1	4	1	1	1	1.45	1	3	4	1	5	2	1	1	2.15
3347400235	1	1	4	1	1	1	1.45	1	3	4	1	5	2	1	1	2.15
3347400245	1	1	4	1	1	1	1.45	1	3	4	1	5	2	1	1	2.15
3347400250	1	1	4	1	1	1	1.45	1	3	4	1	5	3	1	1	2.25
3347400255	1	1	4	1	1	1	1.45	1	3	4	1	5	3	1	1	2.25
3347400265	1	1	4	1	1	1	1.45	1	3	4	1	5	3	1	1	2.25
3347400275	1	1	4	1	1	1	1.45	1	3	4	1	5	3	1	1	2.25
3347400280	1	1	4	1	1	1	1.45	1	3	4	1	5	3	1	1	2.25
3347400285	1	1	4	1	1	1	1.45	1	3	4	1	5	3	1	1	2.25
3347400290	1	1	4	1	1	1	1.45	1	3	4	1	5	3	1	1	2.25
3347400300	1	1	4	1	1	2	1.6	1	3	4	1	5	4	1	1	2.35
3347400310	1	1	4	1	1	1	1.45	1	3	4	1	5	4	1	1	2.35
3347400315	1	1	4	1	1	1	1.45	1	3	4	1	5	4	1	1	2.35
3347400320	1	1	4	1	1	1	1.45	1	3	4	2	5	4	1	1	2.45
3347400325	1	1	4	1	1	1	1.45	1	3	4	1	5	4	1	1	2.35
3347400335	1	1	3	1	1	1	1.3	1	3	4	1	5	4	1	1	2.35
3347400340	1	1	3	1	1	1	1.3	1	3	4	1	5	4	1	1	2.35
3347400345	1	1	3	1	1	1	1.3	1	3	4	1	5	4	1	1	2.35
3347400355	1	1	3	1	1	1	1.3	1	3	4	1	5	3	1	1	2.25
3347401505	1	1	4	2	1	1	1.5	1	3	4	2	5	3	3	1	2.75

3347401605	1	1	4	1	1	1	1.45	1	3	4	1	5	2	3	1	2.55
3347401710	1	1	4	1	1	1	1.45	1	3	4	1	1	4	3	1	2.35
3351400005	4	1	3	1	1	1	1.9	1	2	2	2	5	1	1	5	1.95
3351400010	4	1	3	1	1	1	1.9	1	2	2	2	5	1	1	1	1.75
3351400011	4	1	3	1	1	1	1.9	1	2	2	2	5	1	1	1	1.75
3351400620	4	1	3	1	1	1	1.9	1	2	3	2	5	2	1	1	2
3351400625	4	1	3	1	1	1	1.9	1	2	3	2	5	2	1	1	2
3351400635	4	1	4	1	1	1	2.05	1	2	3	3	5	2	1	1	2.1
3351400690	4	1	4	1	1	1	2.05	1	2	3	2	5	3	1	1	2.1
3351400700	1	1	4	1	1	1	1.45	1	2	3	2	5	3	1	1	2.1
3351400720	1	1	4	1	1	1	1.45	1	2	3	2	5	3	1	1	2.1
3351400800	4	1	3	1	1	1	1.9	1	2	3	2	5	2	1	1	2
3351400825	1	1	4	1	2	1	1.7	1	3	3	2	5	3	1	1	2.2
3351401040	4	1	4	1	1	1	2.05	1	2	3	3	5	2	2	1	2.3
3365900925	1	1	5	1	1	2	1.75	1	4	5	1	5	1	1	5	2.5
3365900975	1	1	5	1	1	1	1.6	1	4	4	1	5	1	5	5	3.15
3365901015	1	1	5	1	1	2	1.75	1	4	5	1	5	2	1	1	2.4
3365901016	1	1	5	1	1	1	1.6	1	4	5	2	5	2	5	1	3.3
3365901035	1	1	5	1	1	2	1.75	1	4	5	1	5	2	5	1	3.2
3365901055	1	1	5	1	1	2	1.75	1	4	5	1	1	2	5	1	2.8
3365901075	1	1	5	1	1	2	1.75	1	4	5	1	1	2	5	1	2.8
3365901775	1	1	5	1	1	2	1.75	1	3	4	2	5	2	1	1	2.25
3365901785	1	1	5	1	1	2	1.75	1	3	4	2	5	2	1	1	2.25
3365901790	1	1	5	1	1	2	1.75	1	3	3	2	5	1	1	5	2.2
3365901791	1	1	5	1	1	1	1.6	3	3	3	2	5	1	5	5	3.4
3365901795	1	1	5	1	1	3	1.9	1	4	4	1	5	1	5	5	3.15
3365901880	1	1	5	1	1	2	1.75	1	4	5	2	1	2	5	1	2.9
3365901881	1	1	5	2	1	2	1.8	3	5	5	2	5	2	5	1	3.8
3365901890	1	1	5	2	1	2	1.8	1	4	4	2	5	2	5	1	3.15
3365901940	1	1	5	1	1	2	1.75	1	4	4	2	5	2	5	1	3.15
3365901945	1	1	5	1	1	2	1.75	1	4	4	2	5	2	5	1	3.15
3365901955	1	1	5	1	1	2	1.75	1	3	4	2	5	2	5	1	3.05
3365901960	1	1	5	1	1	2	1.75	1	3	4	2	5	2	5	1	3.05
3365901970	1	1	5	1	1	2	1.75	1	3	3	2	5	2	5	1	2.9
3365901975	1	1	5	2	1	2	1.8	1	3	3	2	5	2	5	1	2.9
3573200975	5	5	1	4	2	4	3.45	3	1	1	2	5	2	1	5	2.2
3573201061	1	1	2	2	1	4	1.65	1	1	1	2	1	4	3	1	1.8
3779200255	1	1	5	4	1	3	2.05	1	4	3	2	1	1	3	5	2.3
500	4	1	5	1	3	1	2.7	1	3	1	1	1	1	2	5	1.6
501	1	1	3	1	1	2	1.45	1	3	4	1	5	1	1	5	2.25
502	1	1	2	1	1	2	1.3	1	3	4	1	5	3	2	1	2.45
503	1	1	2	1	1	2	1.3	1	3	4	1	5	3	2	1	2.45
504	1	1	2	1	1	2	1.3	1	3	4	1	5	3	2	1	2.45
505	1	1	1	2	1	3	1.35	3	4	2	3	5	3	2	1	2.85
506	1	5	1	1	1	3	2.1	3	1	1	2	1	1	3	5	2.1
507	1	5	1	1	1	3	2.1	3	1	1	3	5	1	3	5	2.6
508	1	5	1	1	1	3	2.1	1	4	1	4	5	1	1	5	2.2

509	1	5	1	1	1	1	1.8	4	4	4	2	5	1	1	5	3.05
510	4	1	2	1	1	1	1.75	3	5	5	1	5	4	1	1	3.1
5367202380	1	1	1	1	1	2	1.15	2	1	2	1	5	2	1	1	1.85
5367202390	1	1	1	1	1	2	1.15	2	1	2	1	5	2	1	1	1.85
5367202410	1	5	1	1	1	3	2.1	2	1	2	1	1	1	1	5	1.55
5367202503	4	1	1	1	1	2	1.75	4	1	1	1	1	2	1	1	1.7
5367202505	4	5	3	4	1	5	3.45	4	3	1	3	5	4	1	5	2.9
5367202510	1	5	1	1	1	2	1.95	2	1	1	2	1	1	1	5	1.5
5367202512	1	5	1	1	1	2	1.95	4	1	1	1	1	1	1	5	1.8
5367202513	1	5	1	1	1	2	1.95	2	1	1	2	1	2	1	5	1.6
5367202514	1	5	1	1	1	2	1.95	4	1	1	1	1	1	1	1	1.6
5367202516	1	5	1	1	1	2	1.95	2	1	1	1	5	1	1	5	1.8
5367202518	4	5	1	1	1	4	2.85	4	1	1	1	1	1	1	5	1.8
5367203415	1	1	1	1	1	4	1.45	2	1	2	1	5	2	1	1	1.85
5367203447	1	1	1	1	1	3	1.3	2	1	2	1	5	2	1	1	1.85
5367203635	1	1	1	1	1	4	1.45	2	1	2	1	5	1	1	1	1.75
5367204080	1	1	2	2	1	3	1.5	1	3	4	2	5	4	2	1	2.65
5367204100	2	1	2	2	2	4	2.1	1	2	4	2	5	4	2	1	2.55
5367204160	2	1	1	1	2	4	1.9	1	2	3	2	5	3	2	1	2.3
5367204180	2	1	1	2	2	4	1.95	2	2	3	2	5	3	1	1	2.3
5367204200	2	1	1	1	1	4	1.65	2	1	2	2	5	2	1	1	1.95
5367204210	5	1	1	1	1	3	2.1	2	1	2	2	5	2	1	1	1.95
5367204505	1	1	2	2	1	3	1.5	3	1	3	2	1	4	2	1	2.3
5367204545	1	1	2	1	1	3	1.45	3	1	2	2	1	3	2	1	2.05
5367204560	1	1	2	1	1	3	1.45	3	1	2	2	1	3	2	1	2.05
5367204565	4	1	1	2	1	4	2.1	4	1	2	2	1	3	1	1	2.05
5422600010	5	1	2	3	1	2	2.2	3	1	1	2	1	4	3	1	2.2
5422600060	2	1	3	3	1	3	1.9	1	1	1	1	1	5	4	1	2
5624200005	2	1	1	2	2	3	1.8	3	3	3	1	1	2	4	1	2.6
5624200006	2	5	1	1	2	2	2.4	3	4	4	1	5	1	4	5	3.35
5624200930	4	5	1	2	2	3	3	1	5	5	3	5	1	4	5	3.4
5624200931	4	5	1	3	3	1	3	3	5	5	1	5	1	4	5	3.6
5624200950	4	5	1	2	1	1	2.45	3	4	4	2	5	1	4	5	3.45
5624200951	1	5	1	1	1	1	1.8	3	4	4	2	5	1	1	5	2.85
5624200970	1	5	1	1	1	1	1.8	4	4	4	2	5	1	4	5	3.65
5624200990	1	5	1	1	1	2	1.95	3	1	1	2	1	2	2	5	2
5624200992	1	5	1	1	1	1	1.8	3	1	1	2	1	1	2	5	1.9
5624201032	5	5	1	4	2	3	3.3	4	1	1	2	1	2	3	5	2.4
5624201038	5	1	2	2	1	3	2.3	3	1	1	2	1	3	1	1	1.7
5729800010	4	1	2	1	1	2	1.9	3	1	1	2	1	4	1	1	1.8
6871200035	2	5	1	1	1	2	2.15	3	1	1	2	5	1	1	5	2.1
6871200045	5	5	1	1	1	3	2.9	3	1	1	2	5	1	1	5	2.1
6871200100	4	1	2	1	1	4	2.2	1	1	2	1	5	3	1	1	1.75
6871200210	5	1	1	2	1	4	2.3	1	1	1	1	5	2	1	1	1.5
6871200350	2	5	1	1	1	4	2.45	1	1	1	1	5	1	1	5	1.6
6871200620	4	5	1	1	1	3	2.7	1	1	1	1	5	1	1	5	1.6
6871200651	1	5	1	1	1	2	1.95	1	1	1	1	5	1	1	5	1.6

6871200660	1	5	1	1	1	2	1.95	1	1	1	1	5	1	1	5	1.6
6871200811	1	5	1	1	1	2	1.95	1	1	1	1	5	1	1	5	1.6
7229500360	4	1	5	1	3	1	2.7	1	3	1	1	1	1	2	5	1.6
7327901195	2	5	1	1	1	1	2	5	5	5	1	5	1	1	5	3.4
7327901215	1	5	1	1	1	3	2.1	5	5	5	1	5	1	1	5	3.4
7327901265	1	1	1	1	1	1	1	5	5	5	1	5	1	1	1	3.2
7327902346	1	5	1	1	1	2	1.95	5	5	5	1	5	1	1	5	3.4
7327902355	2	5	1	1	1	2	2.15	5	5	5	1	5	1	1	5	3.4
7327902395	4	5	1	1	1	3	2.7	3	4	4	1	5	1	1	5	2.75
7327902480	1	1	1	1	1	2	1.15	1	4	4	1	5	2	1	1	2.25
7327902490	1	1	1	1	1	2	1.15	1	4	4	1	5	2	1	1	2.25
7327902500	1	1	1	1	1	2	1.15	1	4	4	1	5	2	1	1	2.25
7327902520	5	1	1	2	1	4	2.3	3	4	4	1	5	2	1	1	2.65
7327903330	1	1	1	1	1	2	1.15	1	4	4	1	5	1	1	1	2.15
7327903331	1	1	1	1	1	2	1.15	1	4	4	1	5	2	1	1	2.25
7327903360	1	1	1	1	1	2	1.15	2	3	4	1	5	1	1	1	2.25
7327903372	1	1	1	1	1	2	1.15	1	4	4	1	5	2	1	1	2.25
7327903645	2	5	1	1	1	4	2.45	2	4	4	1	5	1	1	5	2.55
7327904049	1	5	1	1	1	3	2.1	2	3	3	1	5	1	1	5	2.3
7327904100	1	5	1	1	1	3	2.1	2	3	3	1	5	1	1	5	2.3
7327904135	1	1	1	1	1	2	1.15	1	3	3	1	5	2	1	1	2
7327904190	1	1	1	1	1	2	1.15	1	3	3	1	5	2	1	1	2
7327905280	2	5	1	1	1	2	2.15	1	3	3	2	5	1	1	5	2.2
7327905350	2	1	1	1	1	4	1.65	1	2	3	2	5	2	1	1	2
7327905700	1	1	1	1	1	2	1.15	1	2	3	1	5	2	1	1	1.9
7327905710	1	1	1	1	1	4	1.45	1	2	3	1	5	3	1	1	2
7327905725	1	1	1	1	1	3	1.3	1	2	2	2	5	3	1	1	1.95
7327905750	2	1	2	1	1	3	1.65	1	2	2	2	5	3	1	1	1.95
7327905760	2	1	2	1	1	3	1.65	1	2	2	1	5	3	1	1	1.85
7327905770	1	1	2	1	1	4	1.6	1	2	2	1	5	3	1	1	1.85
7327906515	1	1	2	1	1	2	1.3	1	1	2	1	5	4	1	1	1.85
7327906525	1	1	2	1	1	2	1.3	1	1	2	1	5	3	1	1	1.75
7327906635	1	1	2	1	1	2	1.3	1	1	2	1	5	4	1	1	1.85
7327906645	1	1	2	1	1	4	1.6	1	1	2	1	5	4	1	1	1.85
7327906685	1	1	2	1	1	4	1.6	1	1	2	1	5	4	1	1	1.85
7327906755	1	1	2	1	1	4	1.6	1	2	2	1	5	4	1	1	1.95
7327906770	1	1	1	1	1	2	1.15	3	4	4	1	5	1	1	1	2.55
7340600020	1	1	3	1	1	1	1.3	1	1	2	3	5	2	3	1	2.25
7340600021	1	1	3	1	1	1	1.3	1	1	2	3	5	3	3	1	2.35
7340600022	1	1	3	1	1	1	1.3	1	1	2	3	5	3	3	1	2.35
7340600044	1	1	3	1	1	1	1.3	1	1	2	3	5	2	3	1	2.25
7340600060	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
7340600062	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
7340600080	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600083	1	1	4	1	1	1	1.45	1	1	2	3	5	2	4	1	2.45
7340600085	1	1	4	1	1	1	1.45	1	1	2	3	5	3	1	1	1.95
7340600086	1	1	4	1	1	1	1.45	1	1	2	3	5	2	1	1	1.85

7340600101	1	1	4	1	1	1	1.45	1	1	2	3	5	3	1	1	1.95
7340600103	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600106	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600122	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600124	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600140	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600142	1	1	4	1	1	1	1.45	1	1	2	3	5	4	4	1	2.65
7340600160	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600161	1	1	4	1	1	1	1.45	1	1	2	3	5	4	4	1	2.65
7340600164	1	1	4	1	1	1	1.45	1	1	2	3	5	4	4	1	2.65
7340600165	1	1	4	1	1	1	1.45	1	1	2	3	5	4	4	1	2.65
7340600184	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600201	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340600220	1	1	4	1	1	1	1.45	1	1	2	3	5	3	4	1	2.55
7340601080	1	1	3	2	1	1	1.35	1	3	4	4	5	4	2	1	2.85
7340601081	1	1	3	1	1	1	1.3	1	2	3	3	5	4	3	1	2.7
7344000060	1	1	3	1	1	1	1.3	1	4	4	1	5	1	1	5	2.35
7344000070	1	1	3	1	1	1	1.3	1	4	4	1	5	1	1	5	2.35
7344000080	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	5	2.25
7344000090	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	5	2.25
7344000110	1	1	3	1	1	1	1.3	1	3	4	1	5	1	1	5	2.25
7666207695	2	1	5	4	2	5	2.8	1	5	5	1	5	4	2	1	2.9
7666207786	2	1	5	2	1	4	2.3	1	1	2	1	1	2	1	5	1.45
7666207787	2	1	5	1	1	4	2.25	1	1	2	1	1	1	1	5	1.35
7666207800	1	1	5	2	1	4	2.1	1	1	3	1	1	2	1	5	1.6
7666207810	2	1	5	2	1	4	2.3	1	1	2	1	1	2	1	5	1.45
7666207830	2	1	4	4	2	5	2.65	3	1	3	1	1	5	2	1	2.3
7666207900	2	1	3	3	3	4	2.55	4	1	2	1	1	5	3	1	2.55
7666207905	2	5	2	4	1	5	2.9	3	1	3	1	5	4	1	1	2.4
7666207917	1	1	3	1	1	2	1.45	1	1	2	1	1	5	1	1	1.55
7666700315	2	5	1	2	1	3	2.35	1	1	1	2	1	3	1	1	1.3
7666700350	2	1	2	3	2	4	2.15	1	1	1	2	1	4	1	1	1.4
7666700390	5	1	2	4	1	4	2.55	3	1	1	2	5	4	1	1	2.2
7666700395	5	1	2	1	1	3	2.25	3	1	1	1	1	4	2	1	1.9
7666700510	5	5	1	3	2	3	3.25	3	1	1	1	5	2	1	5	2.1
7666700515	1	1	2	1	1	2	1.3	1	1	1	2	5	3	1	1	1.7
7666700560	2	1	1	1	1	4	1.65	3	1	1	2	1	2	1	1	1.6
7666700755	1	1	1	1	1	2	1.15	1	1	1	2	1	3	1	1	1.3
7666700885	2	1	1	1	1	4	1.65	1	1	1	1	1	2	1	1	1.1
7666701030	2	5	1	1	1	5	2.6	3	1	1	1	1	1	1	5	1.6
7666701040	1	1	1	1	1	2	1.15	1	1	1	1	1	1	1	5	1.2
7666701046	1	5	1	1	1	4	2.25	1	1	1	1	1	1	1	5	1.2
7666701156	1	5	1	1	1	2	1.95	1	1	1	1	5	1	1	5	1.6
7666701216	1	5	1	1	1	2	1.95	1	1	1	1	1	1	1	1	1
7666701220	2	1	1	4	1	4	1.8	3	2	1	1	1	1	1	5	1.7
7666701221	1	5	1	1	1	2	1.95	1	1	1	1	1	1	1	5	1.2
7666701250	1	1	1	2	1	2	1.2	3	1	1	1	1	1	1	5	1.6

7666701275	2	1	1	2	1	4	1.7	3	1	1	1	5	2	1	1	1.9
7666701276	2	1	1	1	1	4	1.65	3	1	1	1	5	2	1	1	1.9
7666701356	1	1	4	5	1	5	2.25	3	1	1	1	5	5	2	1	2.4
7666702850	2	1	4	4	2	5	2.65	1	1	1	1	1	5	2	1	1.6
7666702852	1	1	5	1	1	4	2.05	1	1	1	1	1	5	3	1	1.8
7666702900	2	1	4	3	1	5	2.35	1	1	1	1	1	5	1	1	1.4
7666702901	2	1	4	1	1	3	1.95	1	1	1	1	1	5	1	1	1.4
7666702940	2	1	4	2	1	3	2	1	1	1	1	1	5	1	1	1.4
7666702950	2	1	3	3	1	3	1.9	1	1	1	1	1	5	1	1	1.4
7666702960	2	1	3	3	1	3	1.9	1	1	1	1	1	5	1	1	1.4
7666703000	2	5	1	1	1	4	2.45	3	2	1	1	5	1	1	5	2.1
7666703015	2	1	2	1	1	3	1.65	1	1	1	1	1	4	2	1	1.5
7666703016	2	1	3	1	1	2	1.65	1	1	1	1	1	5	2	1	1.6
7666703017	2	1	3	1	1	3	1.8	1	1	1	1	1	5	2	1	1.6
7666703020	2	1	2	2	1	4	1.85	1	2	1	1	1	4	1	1	1.4
7666703025	2	1	3	1	1	4	1.95	1	1	1	1	1	4	2	1	1.5
7666703030	2	1	2	1	1	4	1.8	1	1	1	1	1	4	2	1	1.5
7666703035	2	1	2	1	1	4	1.8	1	1	1	1	1	4	2	1	1.5
7666703040	2	1	2	1	1	5	1.95	1	2	1	1	1	3	1	1	1.3
7666703050	2	1	1	2	1	3	1.55	2	2	1	1	1	2	1	5	1.6
7666703051	2	5	1	1	1	3	2.3	1	2	1	1	1	1	1	5	1.3
7666703070	2	5	1	1	1	3	2.3	1	2	1	1	1	1	1	5	1.3
7666703090	2	5	1	1	1	3	2.3	1	2	1	1	1	1	1	5	1.3
7666703095	2	5	1	1	1	4	2.45	3	2	1	1	1	1	1	5	1.7
7666703096	2	5	1	1	1	4	2.45	3	2	1	1	1	1	1	5	1.7
7666703100	2	5	1	1	1	3	2.3	1	2	1	1	1	1	1	5	1.3
7666703135	2	5	1	1	1	4	2.45	1	2	1	1	1	1	1	5	1.3
7666703290	2	5	1	2	1	4	2.5	3	3	2	1	5	2	1	5	2.45
7666703291	2	1	1	1	1	4	1.65	1	2	2	1	1	2	1	1	1.35
7666703295	2	5	1	1	1	4	2.45	3	2	2	1	5	1	1	5	2.25
7666703320	2	1	1	1	2	4	1.9	3	3	2	1	5	3	1	1	2.35
7666703321	1	1	1	1	1	2	1.15	1	2	2	1	1	3	1	1	1.45
7666703440	2	1	1	3	2	4	2	3	3	2	1	5	2	1	5	2.45
7666703460	2	5	1	2	3	3	2.85	3	3	2	1	5	1	1	5	2.35
7666703462	1	5	1	1	1	2	1.95	1	2	1	1	1	1	1	5	1.3
7666703464	1	5	1	2	1	2	2	3	3	2	1	5	1	1	5	2.35
7666703530	4	5	1	2	1	2	2.6	3	3	2	1	5	2	1	5	2.45
7666703532	5	5	1	2	1	2	2.8	3	2	1	1	1	1	1	5	1.7
7666703540	2	5	1	2	3	4	3	3	3	2	2	5	2	2	5	2.75
7666703630	2	5	1	3	2	5	2.95	4	3	2	3	5	2	2	5	3.05
7666703670	2	5	1	3	4	1	2.85	3	2	1	3	5	1	1	5	2.3
7666703700	2	5	1	1	1	1	2	1	2	1	3	1	1	1	5	1.5
7666703967	2	1	1	1	1	4	1.65	1	2	2	1	5	3	1	1	1.85
7666703980	1	1	1	1	1	2	1.15	1	2	2	1	1	1	1	1	1.25
7666703985	1	1	1	1	1	4	1.45	1	2	2	1	1	2	1	1	1.35
7666703990	2	1	1	1	1	4	1.65	1	2	2	1	1	1	1	1	1.25
7666704000	2	5	1	1	1	3	2.3	3	2	2	1	1	1	1	5	1.85

7666705084	2	1	2	2	2	4	2.1	3	2	2	1	1	4	1	1	1.95
7666705088	2	1	2	2	2	4	2.1	3	3	2	2	5	4	1	1	2.55
7666705200	2	1	5	2	1	4	2.3	1	1	1	1	1	4	1	1	1.3
7666705205	2	1	5	2	1	3	2.15	1	1	1	1	1	4	2	1	1.5
7666705208	2	1	4	1	1	3	1.95	1	1	1	1	1	5	1	1	1.4
7666705209	1	1	4	1	1	3	1.75	1	1	1	1	5	4	1	1	1.7
7666705210	2	1	4	1	1	4	2.1	1	1	1	1	1	5	2	1	1.6
7666705565	2	1	4	4	2	4	2.5	3	4	2	2	5	5	1	1	2.75
7819500000	1	1	1	1	1	2	1.15	5	5	5	1	5	2	1	1	3.3
7883608601	1	5	1	2	1	2	2	3	5	5	1	5	2	2	5	3.3
7883608603	5	5	1	2	1	2	2.8	3	4	4	2	5	2	2	5	3.15