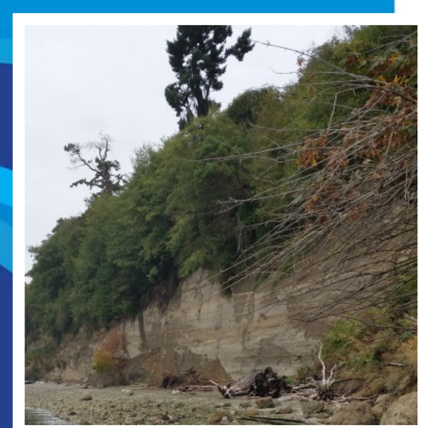
WRIA 6 Nearshore Acquisition Prioritization Framework
FINAL REPORT

Prepared for:

WRIA 6 Lead Entity
Funded by Salmon Recovery Funding Board
November 2019



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WRIA 6 Nearshore Acquisition Framework
FINAL REPORT

Prepared for:

WRIA 6 Lead Entity Coordinator for Salmon Recovery
Island County Department of Natural Resources
Attention: Dawn Spilsbury Pucci

Whidbey Camano Land Trust
765 Wonn Rd, #C201
Greenbank, WA 98253
Attention: Ryan Elting

Authored by:

Phil Bloch
Kelly Muething
Confluence Environmental Company

Paul Schlenger
Environmental Science Associates

Ryan Elting
Whidbey Camano Land Trust

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1.0 INTRODUCTION

The Water Resource Inventory Area (WRIA) 6 Nearshore Acquisition Framework Project was conducted to identify priority nearshore areas to support the recovery of salmonids within Puget Sound, including Puget Sound Chinook salmon and Puget Sound steelhead, which are listed as threatened under the Endangered Species Act. The project area did not include rivers supporting salmonid spawning, but did include areas that provide important early marine rearing habitat for juveniles and migratory corridors for returning adults and out-migrating juveniles from other parts of Puget Sound. The WRIA 6 nearshore has particular importance given its close proximity to the Skagit, Stillaguamish, and Snohomish Rivers, which are all major salmon-producing rivers. A growing body of literature suggests that the early marine growth of juvenile salmon influences their survival rates throughout their entire marine life stages, such that larger juvenile salmon tend to have higher marine survival rates than smaller juvenile salmon (Beamish and Mahnken 2001). There is also the assumption that nearshore conditions beneficial for juvenile salmon also benefit a diverse biological community and the entirety of the ecosystem. Given the role of WRIA 6 habitats in the life cycle of juvenile salmon and the importance of successful juvenile rearing on adult populations, the analysis focused on the ecological needs of juvenile salmon.

A substantial amount of inventory and assessment work has been conducted previously in the project area. The purpose of this project was to integrate the existing available information into a science-based prioritization of shoreline parcels to benefit juvenile salmon. This prioritization considered multiple types of information related to supporting the survival of salmonids. A focus was given to parcels that provide benefits or have the potential to provide benefits to nearshore processes that form and sustain habitats and prey resources contributing to juvenile salmon growth and survival. This project directly addressed the pursuit of grant funding from the Salmon Recovery Funding Board by watershed partners to acquire parcels with conservation and restoration potential. Specifically, this prioritization aimed to synthesize available information to provide a comprehensive interpretation of the priority nearshore parcels for acquisition.

1.1 Project Area

The project area for the study included the entirety of Island County, WA, which consists of Whidbey and Camano islands within the Puget Sound (Figure 1). These islands also make up WRIA 6.

The project specifically considered nearshore parcels that contain shoreline—approximately 6,900 parcels. These parcels were included within the prioritization framework to characterize the relative degree to which each parcel currently supports salmonid survival or have restoration potential.

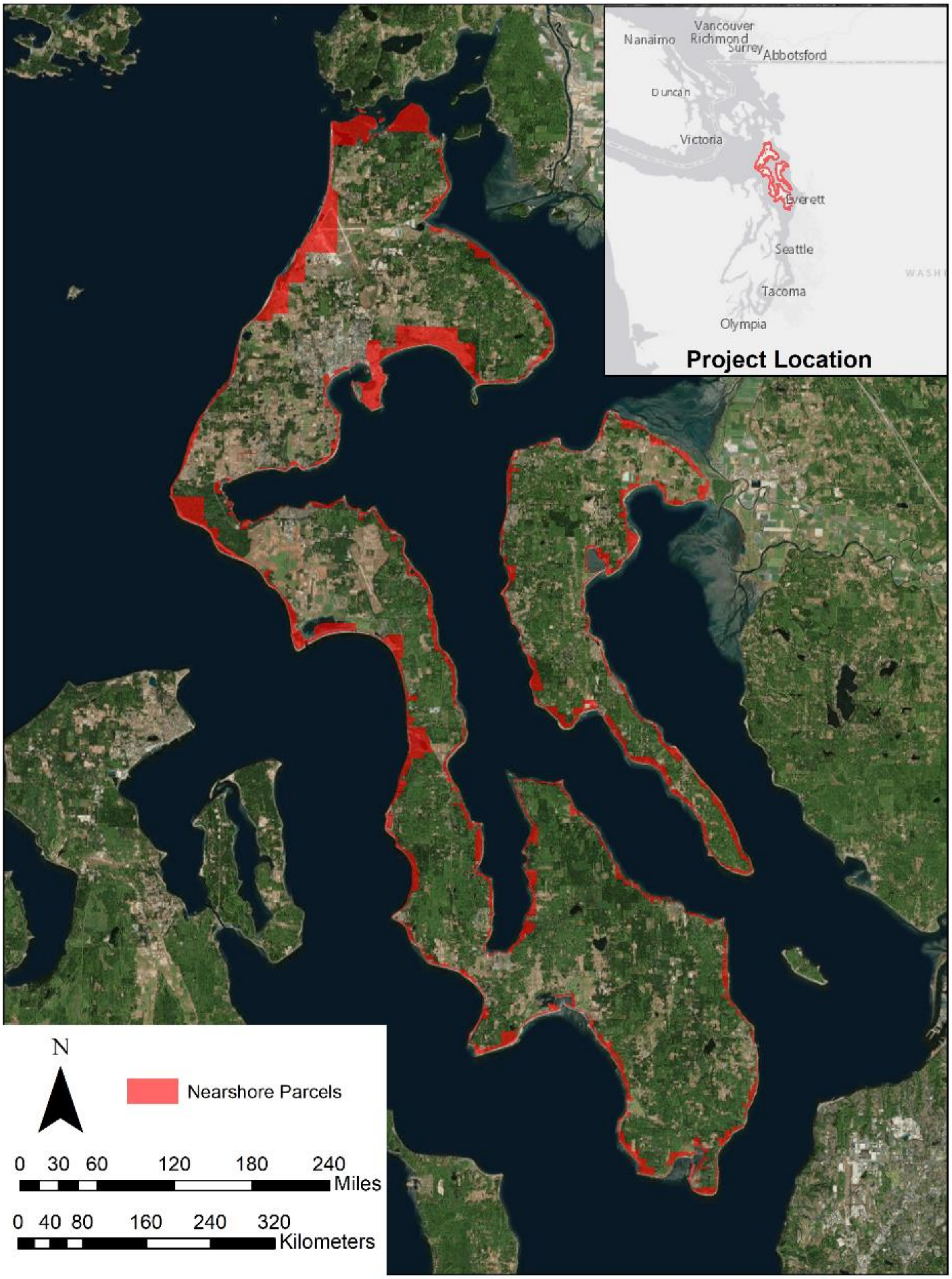

Figure 1. Map of Project Extent

1.2 Juvenile Salmonids in the Nearshore

The project area is not known to contain rivers supporting salmonid spawning in large numbers, but marine nearshore and lower creek reaches in the project area provide rearing habitat for juvenile salmonids originating in other watersheds (e.g., Skagit River, Stillaguamish River and Snohomish River). Species known to spawn in these river systems include Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead (*O. mykiss*), sockeye salmon (*O. nerka*), and pink salmon (*O. gorbuscha*). Juvenile Chinook and chum salmon are the 2 salmon species that use the nearshore and estuarine habitats most extensively (Simenstad et al. 1982, Fresh 2006), while, juvenile coho, pink and steelhead salmonids also use these habitats but to a lesser extent (Beamer et al. 2013). Marine nearshore environments provide distinctly different conditions for juvenile salmon than the freshwater portions of the watershed. The fish encounter changes in water salinity, typically cooler water temperatures, new prey items (often larger in size and energy content), the ebb and flow of tides, new habitat configurations, and different predators and competitors. The amount of time outmigrating salmonids spend in the estuary and marine nearshore varies among species, as well as between stocks and even individuals.

Estuaries and the marine nearshore tend to be highly productive habitats where juvenile salmonids can grow rapidly. Juvenile salmon are opportunistic feeders that tend to forage on a wide diversity of prey types, including benthic/epibenthic prey (e.g., amphipods, copepods, and worms), planktonic/neritic prey (e.g., crab larvae and fish larvae), terrestrial/riparian prey (e.g., insects and spiders), and other fish (Fresh 2006). The availability of prey in these areas is related to the delicate balance of water flow, sediment transport, and organic matter in and through the nearshore. As described by Sibert et al. (1977), *"[n]earshore food webs are noteworthy in that they support abundant prey types that are especially important to small juvenile salmon and because they depend upon internally derived (i.e., from nearshore habitats) sources of organic matter (e.g., eelgrass)*."

Juvenile salmon face several types of predators in the estuary and marine nearshore. Larger fish, birds, and mammals all prey upon salmon (Parker 1971, Fresh 1997). The availability of shallow water to escape larger fish, deeper water to avoid birds/mammals, submerged vegetation, habitat structure (e.g., wood), and even turbidity, can help reduce predation (Simenstad et al. 1982). In addition, the availability of abundant and diverse prey allows juvenile salmon to grow rapidly and outgrow many potential predators.

Prior to and during the transition of juvenile anadromous salmonids from freshwater habitats to brackish water, then salt water, then back again to fresh water as adults, their bodies undergo a major physiological transition (called smoltification) to enable the fish to survive. In large river systems, the increasing salinity gradient occurs over an extended length of the lower river, typically several miles. It is understood that part of the smoltification process occurs after the juvenile salmon enter the marine nearshore (Fresh 2006). Fresh (2006) posits that juvenile salmon habitat use in nearshore ecosystems may be partially driven by physiological needs as the fish complete their acclimation to salt water.

Studies have shown that juvenile Chinook and other salmon species use the pocket estuary habitats of stream systems other than those the fish originated from (i.e., non-natal streams) (Beamer et al. 2003, Hirschi et al. 2003). Pocket estuaries are small embayments associated with creeks and other small freshwater inputs. Beamer et al. (2006) documented that juvenile Chinook salmon use pocket estuary habitats in higher densities than adjacent habitats and pocket estuary restoration was identified as the nearshore strategy in the Skagit Watershed salmon recovery plan (Beamer 2005).

Juvenile Chinook salmon will also move into the freshwater portions of non-natal streams to rear. In a study conducted in more than 70 streams across the Whidbey Basin portion of Puget Sound, Beamer et al. (2013) sampled the lowermost 650 feet of streams too small to support Chinook salmon spawning and documented the regular occurrence of juvenile Chinook salmon. This is an important finding indicating that the lower reaches of creeks should be considered potential rearing habitat for juvenile Chinook salmon migrating along the nearshore even though Chinook spawning does not occur in the creeks. It should be noted that juvenile Chinook salmon rearing in non-natal streams may extend farther upstream than 650 feet, but no sampling was conducted in those areas.

The life cycle of anadromous salmonids includes migration to the ocean, and the availability of suitable migratory corridors is vital. For juvenile salmon that are dependent on the estuary and marine nearshore, the migratory corridor must provide other ecological needs, either continuously as in the case of predator avoidance, or sufficiently to enable the fish to survive and grow. Research has documented that the migration of juvenile salmon from their natal estuaries does not always occur as a directed movement (but at varied paces) toward the ocean. Instead, juvenile salmon distribute widely upon entering Puget Sound (Duffy 2003, Brennan et al. 2004, Fresh 2006), including many that move away from the ocean, thus extending their residency in Puget Sound.

A growing body of evidence shows that the early marine growth of juvenile salmon is important to the overall marine survival of salmon. Beamish and Mahnken (2001) suggested that salmonid survival during the marine phase is regulated at 2 stages: first, the early marine stage, in which increased size leads to decreased predation risk; second, the fall/winter of their first year in salt water, in which increased fitness leads to increased overwinter survival. At that life stage, fitness is linked to growth during the preceding stage. A study by Duffy and Beauchamp (2011) demonstrated the importance of early marine growth on hatchery-origin Chinook salmon. They reported that marine survival to adulthood for hatchery Chinook salmon was most strongly related to their average body size in July, with larger fish experiencing higher survival rates. The highest survival was observed in fish that were greater than 17 grams (approximately 120 mm) by July and released before May. The applicability of this finding for wild Chinook salmon requires additional investigation.

1.3 Previous Assessments in WRIA 6

Since the early 2000s, several assessments have been conducted for all or part of the WRIA 6 project area. Each assessment has been developed with a specific environmental target, with some assessments prioritizing potential protection of existing high-quality habitats, while others prioritized restoration of historic habitats. As part of the Puget Sound Nearshore Ecosystem Restoration Project, a prioritization analysis was conducted to identify restoration opportunities for all of Puget Sound, including the entire Island County. Other available assessments focused on only a portion of the project area. Table 1 lists the existing assessments and identifies the geographic area, analysis overview, and type of recommendations provided. The assessments characterized conditions at different spatial scales that are nested within each other. Full citations of the assessments are provided in the reference section.

The goal for the current assessment is to systematically identify conservation opportunities throughout WRIA 6 using transparent criteria that could be updated as new information or data becomes available. Where possible, the current prioritization uses datasets, analysis methods and outputs from prior analyses.

Table 1. Existing Assessments

Study	Year	Geographic Area	Overview	Type of Recommendations
Conservation Values and Priorities for Drainage Basins Contributing to Triangle Cove and Northwest Port Susan (WCLT 2008)	2008	Triangle Cove and NW Port Susan	Assessment of parcels within drainage basins contributing to Triangle Cove and Kristoferson Creek watersheds	Recommends protection of riparian buffer along streams and protecting the stream headwaters including addressing fish barriers, source of pollution, and large wood debris.
Conservation Values and Priorities for South Camano Drainage Basins (WCLT 2009)	2009	South Camano Island, Island County	Assessment of potential salmon habitat along 4.5 miles of shoreline in South Camano Island	Identified priorities in 4 sub-areas—Pebble Beach, Port Susan, Camano Head wetlands and forests, and Pebble Beach coastal drainage.
Strategies for Nearshore Protection and Restoration in Puget Sound (Cereghino et al. 2012)	2012	Puget Sound	Assessment of degradation, ecological restoration potential, and risk (i.e., watershed development) by shoreform	Management strategy recommendations for beaches, embayments, and coastal inlets at scale of drift cell for beaches and smaller assessment unit scale for other shoreforms.
Feeder Bluff Restoration Assessment for Island and East Jefferson Counties (MacLennan et al. 2017)	2017	Island and East Jefferson Counties	Characterization of feeder bluff restoration opportunities for Island and Jefferson Counties.	Identification of sites that, if restored, would restore sediment supply to shoreline process units through the removal or shoreline armor.

1.4 Project Approach

The project approach had 3 main steps each of which is described in the following sections of the report:

1) Compile input data (biological, physical, etc.) (Section 2.0)
2) Develop prioritization framework (Section 3.0)
3) Evaluate prioritization framework scores for individual parcels (Section 4.0)

This sequence allowed for an understanding of the data that could potentially be included in the framework and then a prioritization of parcels based on actual available data.

To draw upon the expertise and local knowledge of restoration and conservation specialists in the WRIA 6 area, an Advisory Group was assembled for the project. Advisory Group participants included representatives from Island County, Tulalip Tribes, WDFW, and multiple non-profit organizations (Table 2). Some Advisory Group members had participated in preceding studies used in the integration efforts of this prioritization project and were familiar with various relevant data sources. Over the course of the project, the Advisory Group was convened in 3 meetings, one in September 2018, a second in March 2019, and a final in September 2019. The meetings covered the following topics:

- Refinement of project objectives and approach
- Review and identify data sources
- Develop and refine prioritization criteria
- Integration of existing nearshore assessments and priority studies
- Review preliminary results and components of project geodatabase
- Scoring results of prioritization framework and recommendations for revisions
- Final prioritization framework

The Advisory Group provided inputs at these key steps throughout the project. Its role included providing review of interim deliverables, which was instrumental in developing the final prioritization framework.

Table 2. Members of the Advisory Group

Name	Agency / Entity
Dawn Spilsbury Pucci	Island County, WRIA 6 Lead Entity Coordinator
Paul Marczin	Washington Department of Fish and Wildlife
Todd Zackey	Tulalip Tribes
Elsa Carlisle-Schwartz	Restore America's Estuaries
Donald (Kit) Crump	Snohomish County Public Works
Ryan Elting	Whidbey Camano Land Trust
Jessica Larsen	Whidbey Camano Land Trust
Kristin Marshall	Snohomish Conservation District
Matt Zupich	Whidbey Island Conservation District

2.0 INPUT DATA

Data were primarily assembled from public sources of spatial data within Washington. Many Washington state agencies, including the Department of Ecology (Ecology), WDFW, and the Department of Natural Resources (WDNR), host geographic information system (GIS) data repositories (Ecology 2019, WDFW 2019, WDNR 2019). These repositories allow publicly available data about biological and environmental factors to be downloaded and used within a GIS software. Island County also has a GIS repository that includes property, transportation infrastructure, and some physical data for the entire county (Island County 2019). Additional data were obtained from the National Oceanic and Atmospheric Administration (NOAA) and the Tulalip Tribes. Details of each dataset and how it was used within the framework are described below.

Datasets and survey efforts that were heavily relied upon include the Washington State ShoreZone Inventory collected by WDNR, and the Beach Strategies project prepared by Coastal Geologic Services, Inc. (CGS). These datasets represent compilations of shoreline data throughout the Puget Sound and beyond. Data for the ShoreZone Inventory were collected between 1994 and 2000 through the WDNR's Nearshore Habitat Program. The ShoreZone Inventory describes physical and biological features of intertidal and shallow subtidal areas within all of Washington State nearshore marine waters (WDNR 2001). The Beach Strategies project was prepared for the Estuary and Salmon Restoration Program (ESRP). The overarching goal was to develop a dataset of the best-available information for nearshore managers to use in decision-making and recovery management (CGS 2017). Key information in the dataset includes high-resolution shoreline armor mapping, erosion potential (based on fetch), and drift cell identification. These data are compatible with the ShoreZone shoreline, allowing for straightforward combination of the information in each dataset.

The prioritization framework described here was developed to the parcel level. Because the goal of this framework was for it to inform acquisition decisions, parcel-level data allows for clear guidance when deciding if resources should be dedicated to acquiring a specific parcel. The parcel layer obtained from Island County contained all parcels on both Whidbey and Camano islands. The first step was to select out the nearshore parcels by exporting just those parcels that overlapped with mapped shoreline data. Following this step, it was clear that the layer included extraneous polygons and parcels, so a cleaning process was completed by comparing the Island County parcel layer to the parcel layer used in the Beach Strategies project. The final parcel layer used in the framework development and scoring included 6,859 parcels along the shoreline of Whidbey and Camano islands.

Available data were divided into 3 main categories to assess the conservation potential of each parcel: landscape context, ecosystem processes, and habitat function. Landscape context data related to the location and size of the parcel, as well as general land use. Ecosystem processes data characterized the physical processes occurring within the parcel that help to shape the quality of the ecosystem and habitat provided. Finally, habitat function data included presence of important aquatic and nearshore habitat features. An additional category of data was assessed to quantify the restoration potential of each parcel, looking specifically at the possibility for removal of armoring or overwater structures.

2.1 Landscape Context Data

The data included in this section were primarily obtained from the Island County GIS repository (Island County 2019). Parcel data were obtained from the Island County Assessor's Office; this data is updated nightly. Relevant data associated with each parcel (i.e., acreage and taxpayer) were retained within the dataset of nearshore parcels. Taxpayer information was used to identify whether a parcel was owned by a park service (county or state) or the Whidbey Camano Land Trust and would therefore already have a certain level of protection. Additionally, Island County has previously defined Salmon Priority Areas based on location and proximity to the mouth of the Skagit, Stillaguamish and Snohomish Rivers. These areas were included to characterize potential importance of certain parcels to salmon at a broad scale. The Beach Strategies dataset included information about the length of the shoreline and a description of the primary land use of each parcel. Finally, information from Island County about the location of an aquatic reserve offshore of Whidbey Island was included as another example of current conservation. These attributes further contextualize the location and conservation potential of a given parcel.

2.2 Ecosystem Processes Data

Data in this category were pulled together from WDFW, the Beach Strategies dataset, and Island County. The goal of these data was to characterize the potential habitat and quality of the habitat present within a given parcel. Stream information, including the location, gradient, and fish presence, was obtained from WDFW and attributed to each parcel based on the location of the stream mouth and the watershed of the parcel. Shoretype, as assessed within the Beach Strategies survey effort, was included to capture the locations of embayments and potential pocket estuaries along the shoreline. Additionally, the erosion potential provides information about physical processes acting on the shoreline. Finally, data on the location of structures from Island County were used to determine parcels that have structures within 200 feet of the shoreline.

2.3 Habitat Function Data

This category contained data from WDNR's ShoreZone dataset, WDFW surveys, and the NOAA's Coastal Change Analysis Program (C-CAP). These data represent an assessment of the functionality of the nearshore marine habitat adjacent to the parcels within the framework. Information about the presence or absence of eelgrass from the ShoreZone dataset was used to quantify the potential structure provided in the nearshore habitat. WDFW maintains data on forage fish spawning locations collected by individuals and groups trained in approved survey methodologies. This forage fish spawning data provided information about the presence of this important prey resource. Finally, the C-CAP data include information about the coastal land cover. This raster data allowed for summarization of the level of natural versus developed area within 200 feet of the shoreline in each nearshore parcel, which contributes to the functionality of the nearby aquatic habitat.

2.4 Restoration Potential Data

The data in this category were separated out to clearly distinguish between conservation and restoration goals. Parcels that would be prioritized for acquisition are often relatively undeveloped and have high conservation potential. In contrast, parcels that would be prioritized for restoration may already be developed but show potential for restoration through removal of structures or improvement of habitat quality. The data included in this section detail the presence of shoreline armoring and overwater structures. The armoring information was obtained from the Beach Strategies dataset, and the overwater structures dataset came from WDNR. Inclusion of these data allowed for the identification of parcels that could be restored by removing armoring or overwater structures.

3.0 PRIORITIZATION FRAMEWORK METHODS

The prioritization framework is a scoring framework developed to characterize the relative degree to which of each parcel currently supports salmonid habitat. A prior framework applied to South Camano Drainage Basins provided a starting place for developing and evaluating criteria (WCLT 2009). This framework was adapted to emphasize Chinook salmon-centric valuation criteria and criteria that could be applied throughout Island County.

The overall prioritization framework incorporates three components that when combined characterize the ecosystem function of the site for Chinook salmon and describe the potential conservation value of conserving a site. The three components of the framework are landscape context, ecosystem processes, and habitat function. The condition of each element is characterized by scoring the condition of several attributes. The scoring system was developed based on input from the Advisory Group and considered the distribution of data values. Where appropriate, scoring values were chosen by assessing the statistical distribution or inherent categories within the data, with input from the Advisory Group.

Calculations are made for individual parcels and groups of parcels may create different values and can be re-calculated using the methods described here. The higher the score indicates the greater the contribution to salmon benefit. The maximum score is 100. The total score represents the priority assigned to a given parcel for acquisition and conservation.

The prioritization framework also includes a separate calculation of restoration potential. The restoration potential is presented as a separate score because restoration goals consider the potential ecological value of sites that may be impaired.

3.1 Landscape Context Score

Landscape context describes the characteristics and uses of adjacent and nearby areas in evaluating a site. The landscape context category has a maximum score of 26. Scoring rules for each of the prioritization attributes are included in Table 3. Details on the rationale behind the grouping and scoring are provided below.

The size of the parcel was scored based on the statistical spread of acreages and meaningful breaks within the range of values. Larger parcels received a higher score because of greater potential for conservation. The taxpayer or owner of the parcel was used to identify parcels adjacent to those that are already protected or conserved in some manner. Taxpayers that were considered included Washington State Parks, Island County & Parks Department, and Whidbey Camano Land Trust. Parcels received points for being adjacent to a protected parcel because proximity could improve the potential for conservation success and connectivity between habitats. Parcels that were adjacent to the established Smith & Minor Islands Aquatic Reserve on the west side of Whidbey Island also received points in this category. The aquatic reserve borders shorelines between approximately Fort Ebey State Park and Joseph Whidbey State Park. Scores based on the salmon priority area were clearly assigned, with the most points going to parcels in Area 1, followed by Areas 2 and 3. The length of shoreline was used to approximate potential nearshore habitat within the parcel. The spread of data was assessed, and meaningful break points were used to give the points to parcels with greater shoreline lengths.

Information on the importance and available data to support each landscape context component was compiled and the relative importance of each habitat attribute was considered in generating prioritization scores for landscape context components (Table 3). Draft scores were presented to the Advisory Group and updated based on their feedback.

Table 3. Scoring Rules for the Landscape Context Component of the Prioritization Framework

Prioritization Attribute	Description	Maximum Score	Scoring
Acreage	Size of parcel in acres using ArcGIS geometry calculations	4	4 → >25
			3 → 10-25
			2 → 2-10
			1 → 0.5-2
			0 → 0-0.5
Parcel Neighbors	Taxpayer/owner of the parcel	3	3 → Parcel is adjacent to a parcel that is already protected (park/WCLT land/etc. and aquatic reserve)
			0 → Otherwise
Salmon Priority Area	Previously identified priority areas for salmon	15	15 → Area 1
			5 → Area 2
			0 → Area 3
Length of Shoreline	Sum of shoreline segments of each parcel	4	4 → >2,000 feet
			3 → 1,000–2,000 feet
			2 → 500–1,000 feet
			1 → 100–500 feet
			0 → <100 feet

3.2 Ecosystem Processes Score

Ecosystem processes are interactions between physicochemical and/or biological attributes that contribute to the production of Chinook salmon. The ecosystem processes category captures many characteristics that are associated with salmon production and has a maximum score of 54. Scoring rules for each of the prioritization attributes are included in Table 4. Details on the rationale behind the grouping and scoring are provided below.

Although many of the streams in Island County flow seasonally and do not provide habitat for spawning salmon, studies by Beamer et al. (2013) demonstrated that fry migrant Chinook salmon may use small stream systems as rearing habitat. Areas adjacent to streams may also provide important rearing habitat for shore-oriented juvenile salmonids entering or exiting stream systems. Therefore, distance to stream measured as the presence of stream on parcels and buffers around stream mouths were prioritized as important habitats and assigned the highest scores.

Beamer et al. (2013) and Zackey et al. (2015) found that non-natal stream use decreases with distance from natal systems. In the initial stream scoring, streams were scored based on the type as identified by the Island County stream database. However, multiple thresholds were incorporated based on field measurements reported by Zackey et al. (2015) to prioritize areas near natal stream systems. Use of non-natal streams is likely affected by the accessibility of the lower stream segments. Therefore, streams with gradients of less than 6%, a gradient that juvenile salmonids can access, with substantial stream length were prioritized as potential juvenile habitat.

Habitat use by various species of fish, including salmonids (e.g., Toft et al. 2007) and forage fish (Pentilla 2007), is associated with the physical structure of the shoreline or shore type. These attributes of shorelines suggest forage, movement or predator avoidance behaviors may be occurring. Parcels adjacent to pocket estuaries were given the highest scores, as these locations provide important nursery and foraging habitats. Accretion shoreforms and shoreforms that include sediment supplies were also given the high values.

Beaches can change over time depending on the sediment supply, sediment transport and erosion processes (Shipman et al. 2014). Erosion potential is a combination of the shoretype and the fetch[1] to a site, which generates an index of the potential for a site to be eroded. Sites with high erosion potential are an important context for considering nearshore management and may lead to loss of site features if sources of sediment such as feeder bluffs and erosion control are not considered to maintain habitat (CGS 2017). Beaches with lower erosion potential are likely to be more stable and were therefore given higher values.

Shoreline buffers are important for a number of ecological processes, including the potential for shoreline erosion to provide sediment to support beach maintenance and formation, as well as for riparian areas to contribute shading and prey resources to the upper intertidal. One metric for the potential ecological function of the shoreline buffer is the distance from the shoreline to upland structures. Parcels where structures are absent or set back more than 200 feet from the shoreline are likely to maintain natural or semi-natural buffers adjacent to the shoreline. These parcels were given higher priority than parcels where structures are closer to the shoreline.

Information on the importance and available data to support each ecosystem process component was compiled and the relative importance of each habitat attribute was considered in generating prioritization scores for ecosystem process components (Table 4). Draft scores were presented to the Advisory Group and updated based on their feedback.

[1] Distance of the water surface over which the wind blows to generate waves.

Table 4. Scoring Rules for the Ecosystem Processes Component of the Prioritization Framework

Prioritization Attribute	Description	Maximum Score	Scoring
Distance to Stream	Used synthetic streams layer built using the software package "NetMap"	6	6 → stream on parcel 3 → <0.25 miles to a stream 0 → >0.25 miles to a stream
Salmon Presence in Stream	Used regulatory streams layer from Island County	8	8 = Type F stream 4 = Type N stream 0 = Otherwise
Potential Juvenile Habitat	Used synthetic streams layer to estimate stream length where gradient is less than 6%	8	8 → 150–300 feet 0 → 0–150 feet
Shoretype	Dominant shoretype, either Pocket Estuary (PE), Accretion Shoreform (AS), Feeder Bluff (FB), Feeder Bluff Exceptional (FBE), No Appreciable Drift (NAD)–Artificial, NAD–Bedrock, NAD–Delta, NAD–Low Energy, Pocket Beach, or Transport Zone	16	16 → PE 8 → FB, FBE, PB 4 → other AS 0 → otherwise
Erosion Potential	Values 1-8; scoring equals erosion potential value	8	8 → 8 7 → 7 6 → 6 5 → 5 Etc.
Structure near Shoreline	Based on building footprints	8	8 → parcels with structures >200 feet from shoreline 4 → parcels with structures between 100–200 feet from shoreline 0 → parcels with structures within 100 feet of shoreline

3.3 Habitat Function Score

The habitat function category has a maximum score of 20. Scoring rules for each of the prioritization attributes are included in Table 5. Details on the rationale behind the grouping and scoring are provided below. Habitat functions are associated with mapped or documented habitat attributes that are associated with salmonid use or productivity.

Fish, including juvenile salmonids, use eelgrass beds as migratory corridors as they move along the nearshore and may benefit from predator protection and food resources associated with eelgrass (Mumford 2007). Although few organisms feed directly on live eelgrass leaves, eelgrass is a major contributor to the Puget Sound food web through energy transfers from detrital (dead) leaves, which support detritivores and ultimately fish and other higher-level consumers (e.g., Thayer and Phillips 1977). Eelgrass is also considered to be a sensitive indicator of coastal ecosystem health (Marbà et al. 2013) and its continued presence in an area is a positive indicator of ecosystem function. Therefore, higher scores are assigned for eelgrass presence.

Eelgrass in Puget Sound can be broadly divided into 2 categories—flats and fringes. Flats are characterized by broad, shallow slopes, typically in embayments and river deltas. Fringe sites are characterized by steeper slopes. The lower edge of the eelgrass bed is controlled by light conditions; therefore, flats tend to be larger areas given an equivalent length of shoreline. Due to the association of flats with habitats associated with juvenile salmon transition and nursery habitats, including pocket estuaries, and stream and river deltas, these habitats were assigned greater value than fringe sites.

Marine growth and survival of salmonids depends in part on the quality and quantity of prey items consumed during early developmental stages. Duffy et al. (2010) documented a link between terrestrial insects and marine feeding of Chinook salmon, suggesting that riparian conditions along shorelines affect feeding opportunities for these fish. Nearshore riparian conditions may also affect prey items for juvenile and older life stages of salmonids. Rice (2006) documented the benefits of riparian shade for shoreline spawning microclimates on beaches used by surf smelt. Forage fish such as surf smelt represent an important prey resource for both juvenile and adult salmonids. Shoreline riparian conditions adjacent to the shoreline were given higher values if they offered natural habitats that are likely to provide shade and insect prey items to the nearshore.

Forage fish (smelt, sand lance, anchovy, and Pacific herring) are important prey items for juvenile salmon. Larval and juvenile Pacific sand lance comprised a significant portion of juvenile Chinook salmon prey items (Duffy et al. 2010). In general, forage fish comprise a prey resource for many of the higher level predators in Puget Sound (Penttila 2007). Forage fish spawning areas are important resources for production of forage fish resources and supporting the broader Puget Sound food web. Therefore, forage fish spawning areas were assigned high prioritization values.

Information on the importance and available data to support the habitat function component was compiled and the relative importance of each attribute was considered in generating prioritization scores for habitat function (Table 5). Draft scores were presented to the Advisory Group and updated based on their feedback.

Table 5. Scoring Rules for the Habitat Function Component of the Prioritization Framework

Prioritization Attribute	Description	Maximum Score	Scoring
Eelgrass Presence	Eelgrass documented along at least a portion of the parcel's shoreline	6	6 → Eelgrass along shoreline 0 → Otherwise
Eelgrass Potential Habitat	Documented flat or fringe habitat adjacent to the parcel's shoreline	2	2 → Flat identified along shoreline 0 → Otherwise
Land Cover/Riparian Vegetation	Fraction of natural vs. developed land within 200 feet of shoreline	6	6 → >50% natural/undeveloped land 0 → <50% natural/undeveloped land
Forage Fish Spawning	Documented observation of sand lance or surf smelt spawning	6	6 → either sand lance or surf smelt spawning 0 → neither

3.4 Restoration Need Score

The restoration potential category has a maximum score of 65. Scoring rules for each of the prioritization attributes are included in Table 6. Details on the rationale behind the grouping and scoring are provided below. Restoration priority identifies anthropogenic impacts and gives points for the potential removal of these features which may be limiting ecosystem functions (e.g., Dethier et al. 2016).

Shoreline armoring and nearshore structures can impact a variety of ecosystem functions and services provided by beaches. Structures that extend into the intertidal zone lead to a notable decrease in the number of beach logs and wrack that can accumulate and prevent the upper beach from retaining material between high tides (Dethier et al. 2016). Forage fish that spawn in the upper intertidal zone are impacted by structures because spawning habitat is lost (e.g., Quinn et al. 2012) and because the structures can change the suitability of the habitats for egg deposition and incubation survival. For the restoration potential parcels with the larger amount of armor are prioritized higher due to the amount of improvement that can be gained by removing the armor.

Overwater structures pose potentially significant effects on salmonids because the low light levels under and near overwater structures limits eelgrass/macroalgae growth and can alter juvenile salmon movements in order to avoid dark areas. The salmonids will either delay movements, staying near shore, or move offshore along the dock edges (e.g., Nightingale and Simenstad 2001). Salmonids that are shore oriented at juvenile life stages that move offshore are susceptible to increased predation risk and have less access to preferred prey resources (e.g., Fresh 2006). Therefore, parcels with overwater structures were assigned higher value in the prioritization framework than sites with structures due to the potential improvements associated with removal of those structures.

Structures along the shoreline, in addition to overall development near the shoreline, also provides information about the quality of riparian habitat. Riparian vegetation can contribute shading and prey resources to the nearshore, adding to the productivity of the habitat. Assessing the amount of development and presence of structures within 200 ft of the shoreline provides an indication of the quality of the terrestrial habitat that is influencing the marine habitat. Parcels with greater levels of development within the shoreline buffer scored higher because of the greater potential for restoration.

Finally, sites where diking has occurred in the past were identified. Parcels near these areas were given points because of the high potential for restoration and recovery of wetland habitat. The specific locations are noted below in Table 6.

Information on the importance and available data to support the restoration need component was compiled and the relative importance of each attribute was considered in generating prioritization scores for restoration need (Table 6). Draft scores were presented to the Advisory Group and updated based on their feedback.

Table 6. Scoring Rules for the Restoration Potential Component of the Prioritization Framework

Prioritization Attribute	Description	Maximum Score	Scoring
Armoring Presence	Armoring considered present if any segments along the parcel's shoreline are armored	15	15 → armoring on >75% of shoreline
			10 → Armoring on <75% and >25% of shoreline
			5 → Armoring on <25% and >5% of shoreline
			0 → Armoring on <5% of shoreline
Presence of Overwater Structures	Includes small docks, large docks, bridge, fill, buoy/float	10	10 → overwater structures present within parcel
			0 → no overwater structures within parcel
Stream Barriers	Includes culverts, tide gates, and potential road crossings within 300 ft of shoreline	15	15 → yes
			0 → no
Riparian Condition	Percentage within 200 ft of shoreline	6	0 → 75-100% unnatural
			2 → 50-75% unnatural
			4 → 25-50% unnatural
			6 → 0-25% unnatural
Structures within Shoreline	Distance to structure	4	0 → >200 ft
			2 → 100-200 ft

Prioritization Attribute	Description	Maximum Score	Scoring
			4 → 0-100 ft
Diked sites/wetland opportunities	Used identified areas that have been diked (Dugualla, Deer Lagoon, Cultus Bay, Iverson, Arrowhead Lagoon, Livingston Bay, Crescent Harbor, NW Davis Slough, SW Triangle Cove, Greenbank Lagoon, Maxwelton)	15	15 = parcels near identified areas
			0 = otherwise

4.0 PRIORITIZATION FRAMEWORK RESULTS

A total of 6,860 nearshore parcels in WRIA 6 were assigned scores based on the prioritization framework. Figure 2 provides a geographic overview of the prioritization scores, and Appendix A summarizes these scores in a tabular format by parcel number. Prioritization scores shown in Figure 2 are displayed in six groups based on Jenks natural breaks in the scoring for each parcel. Appendix B provides maps showing input data used to support the prioritization framework. The total number of parcels includes 128 publicly owned parcels that were removed from visualization and analysis because of their current protection status or lack of acquisition potential. Of the remaining 6,732 parcels, the overall prioritization scores ranged from 6 to 87 with a mean of 37.5 (Figure 3). The potential scores for parcels ranged between 0 and 100.

Component scores leading to the overall conservation prioritization score have a normal distribution around the central mean. Each parcel's prioritization score can be broken down into its landscape context, ecosystem process and habitat function scores. Individual components have different distributions. Landscape context is heavily skewed so very few parcels receive high scores, and an intermediate number of parcels receive mid-level scores, and most parcels receive low scores. The ecosystem process scores are normally distributed about a central predictor, and as these comprise the majority of the overall score, this distribution is similar to the overall score distribution. Habitat function scores are skewed such that there are many more sites with relatively high scores than those with lower scores.

Table 7. Summary Statistics for Component Prioritization Scores

Prioritization Category	Minimum	Maximum	Mean	Standard Deviation
Landscape Context (max of 20 points)	0	25	8.0	5.3
Ecosystem Processes (max of 60 points)	1	50	17.6	6.8
Habitat Function (max of 20 points)	0	20	11.9	5.3
Overall Score (max of 100 points)	6	87	37.5	11.1

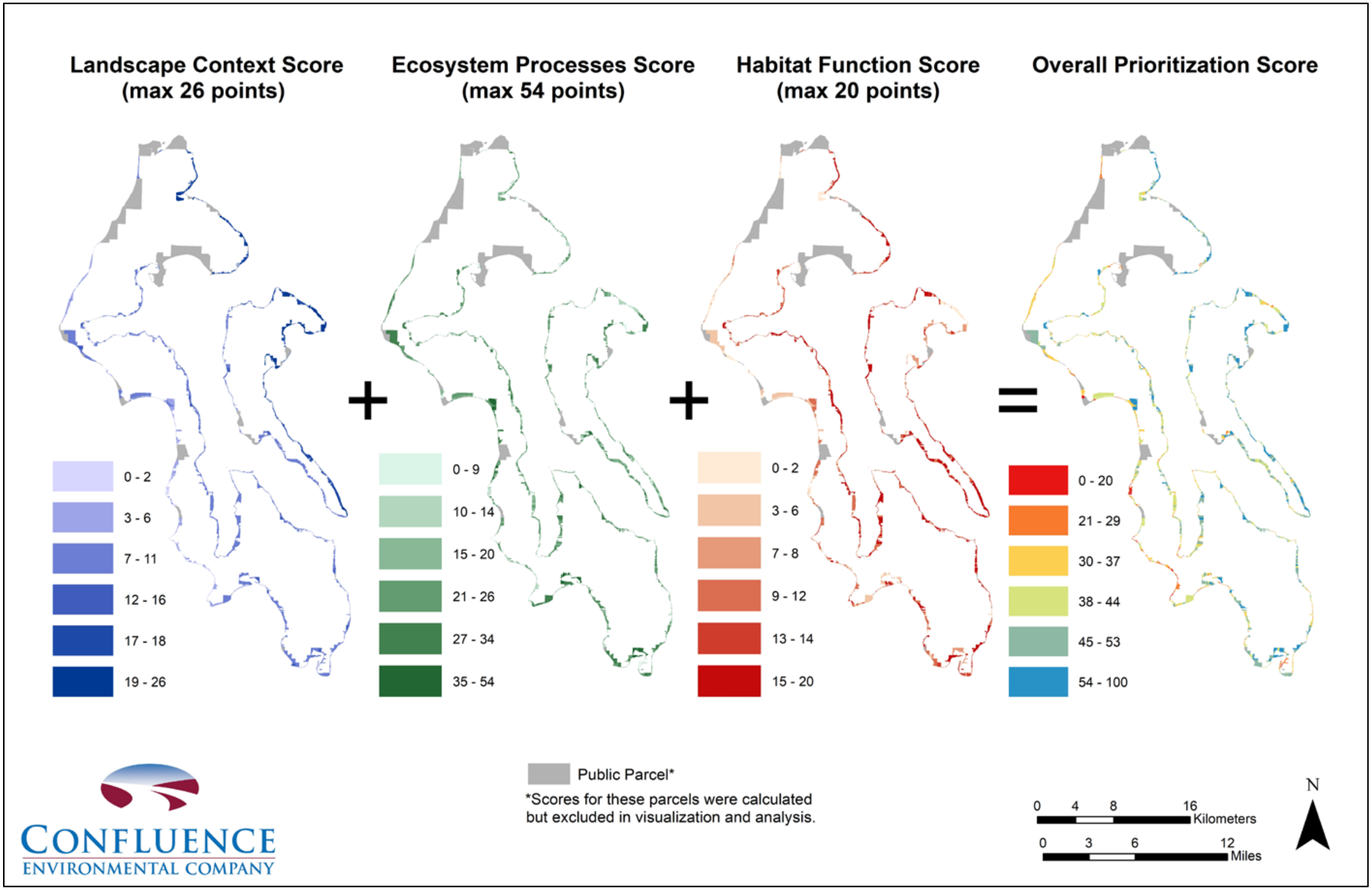

Figure 2. Overall Prioritization Score Map Summary

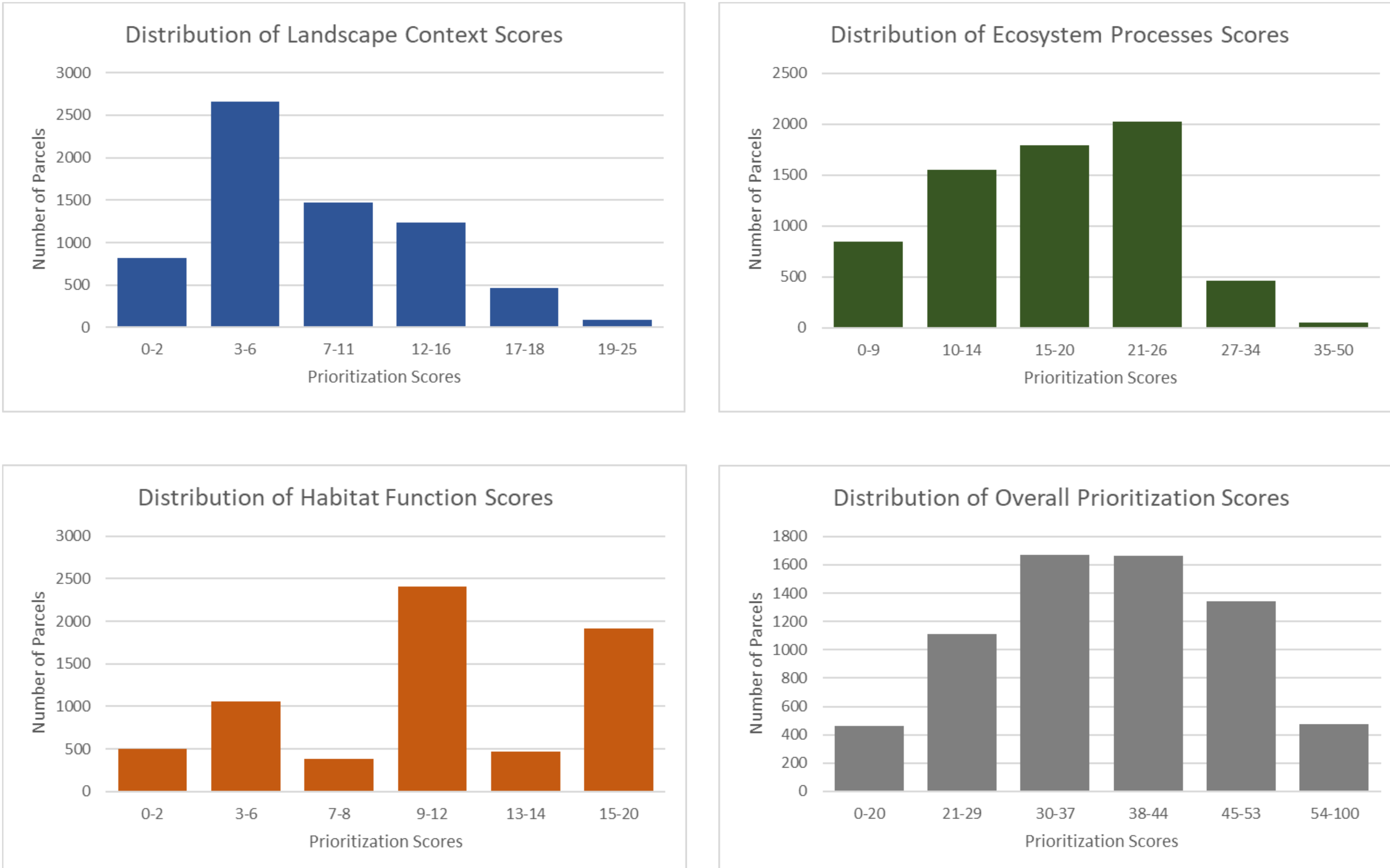

Figure 3. Histograms of Results for each Prioritization Category

During previous salmon recovery planning work, WRIA 6 has identified 3 tiers of priority zones for conservation actions. Area 1 represents shoreline areas along Whidbey and Camano islands that are within 5 miles of the Skagit, Stillaguamish, and Snohomish deltas that are expected to support juvenile salmonids originating in these major river systems. Chinook salmon prioritization scores for nearshore parcels in Area 1 are shown in Figure 4. Parcels had an average score of 44.8, with a minimum of 21, maximum of 87 and standard deviation of 9.5.

Area 2 represents medium priority areas for salmonids that are within the Whidbey Basin, which has been regionally recognized as important to all south and central Puget Sound stocks. This area also includes a portion of Southeast Admiralty Inlet and Northwest Whidbey Island because these areas are likely to be used by juvenile salmon. This represents primarily shorelines in Saratoga Passage which are relatively sheltered between Whidbey and Camano islands. Chinook salmon prioritization scores for nearshore parcels in Area 2 are shown in Figure 5. Parcels had an average score of 37.6, with a minimum of 10, maximum of 79 and standard deviation of 9.0.

Area 3 represents lower priority areas for salmonids that are not adjacent to any rivers with natal populations and include habitats likely to be impacted by high wave and current energy. This represents primarily shorelines along the western shoreline of Whidbey Island adjacent to Admiralty Inlet. Chinook salmon prioritization scores for nearshore parcels in Area 3 are shown in Figure 6. Parcels had an average score of 25.6, with a minimum of 6, maximum of 55 and standard deviation of 9.6.

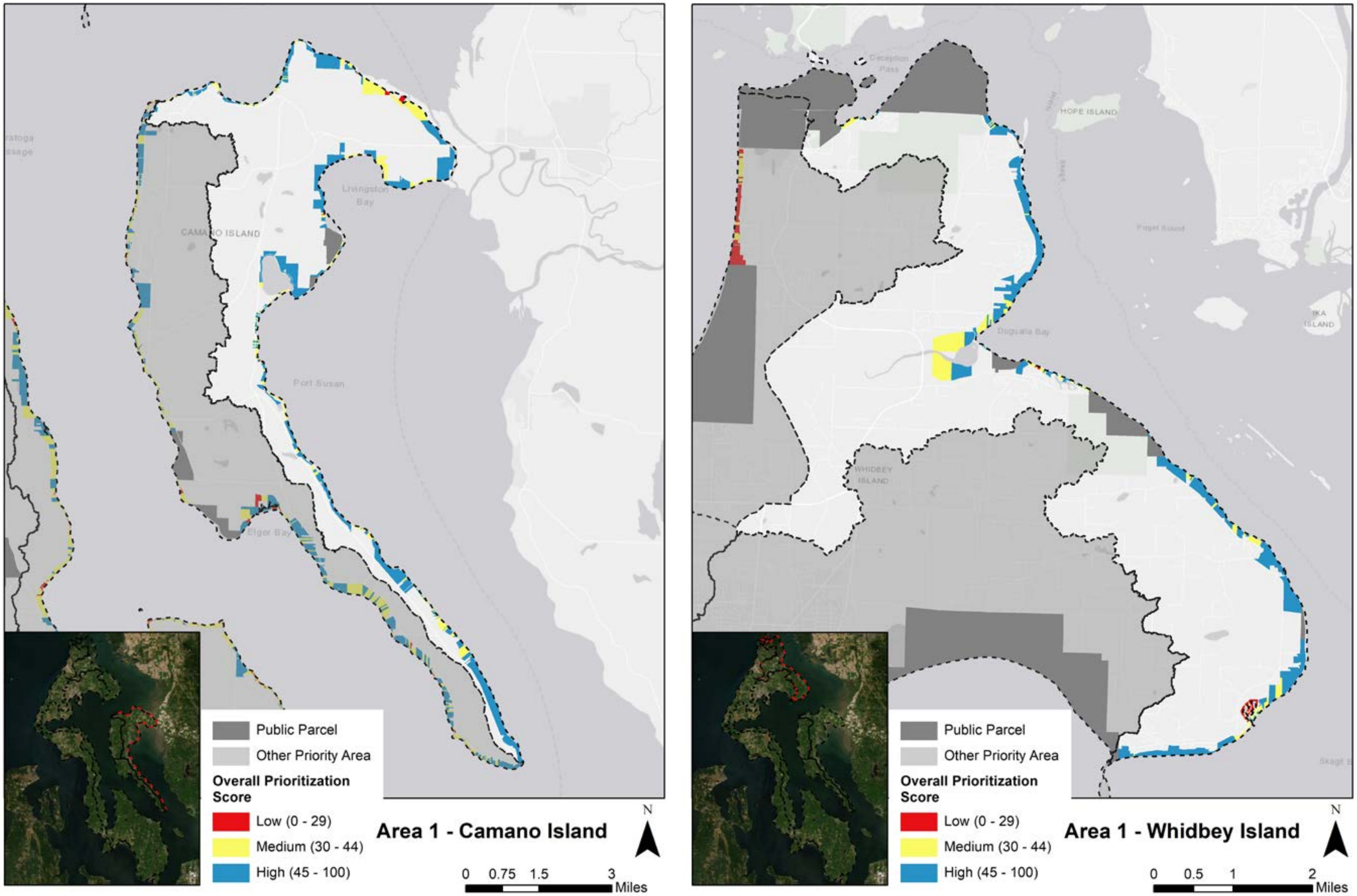

Figure 4. Overall Prioritization Scores within Salmon Priority Area 1

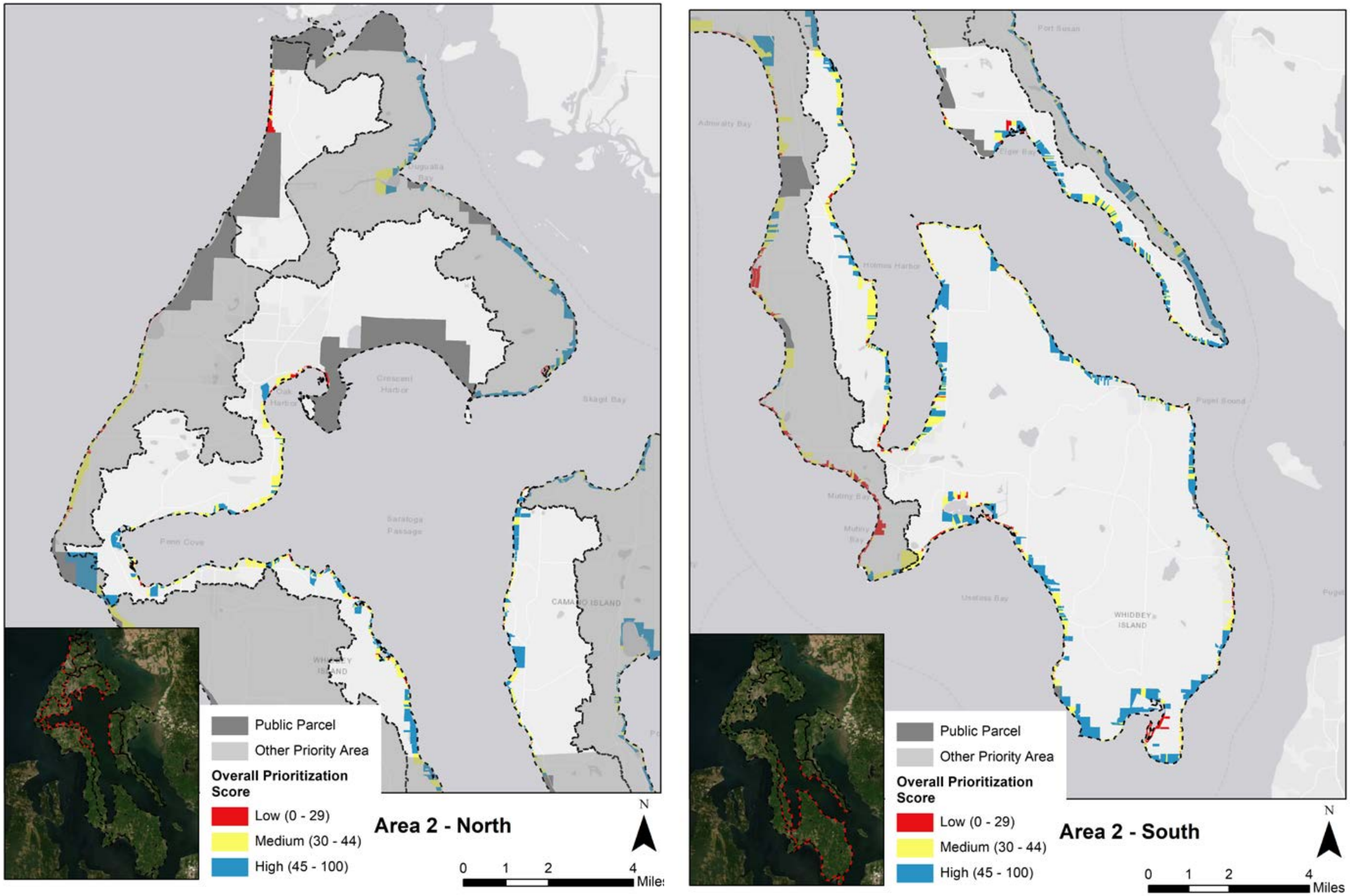

Figure 5. Overall Prioritization Scores within Salmon Priority Area 2

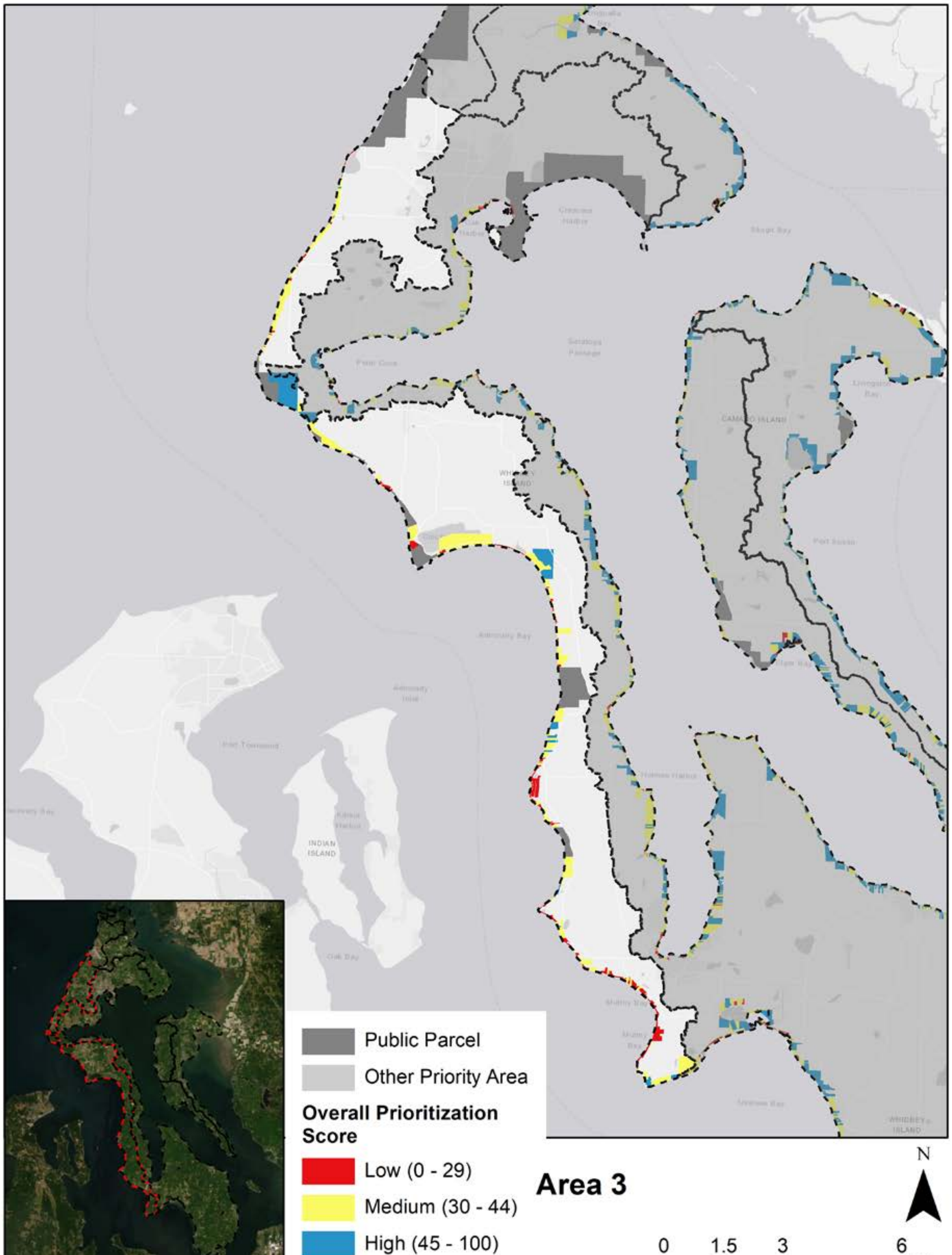

Figure 6. Overall Prioritization Scores within Salmon Priority Area 3

4.1 Restoration Need Results

Restoration need provides an indication of the potential uplift a site may achieve if anthropogenic structures and habitat modifications are removed. Restoration potential is neither additive nor detracting from conservation potential. Instead it is a different consideration, which often follows consideration of the conservation value of a site. Functionally, removal of anthropogenic constraints on ecological function may not improve the overall conservation score under this prioritization framework, but likely would improve the individual ecosystem functions. For those sites considered for acquisition, the restoration potential score provides an indication of the magnitude of restoration work needed to remove impairments to ecosystem functions.

Restoration need scores had a possible range of 0 to 65, with an actual maximum of 50. The mean is relatively low (12.6), but this is likely related to large portions of the total score depending on a few criteria (see Table 6).

Table 8. Summary Statistics for Restoration Need Prioritization Scores

Prioritization Category	Minimum	Maximum	Mean	Standard Deviation
Restoration Need (max of 65 points)	0	50	12.6	10.4

Jenks natural breaks were used to define high, moderate, and low classes of restoration need scores. High scoring parcels received scores between 27 and 50, Moderate between 12 and 26 and Low between 0 and 11. Table 9 shows these tiered classes broken down by Salmon Priority Area.

As discussed above, the Salmon Priority Areas have been defined by Island County based on proximity to important salmon-bearing rivers. Within the Conservation Priority scoring, parcels in Area 1 (see Figure 4) received the highest points. Parcels that also scored high for Restoration Need in this area represent locations that could provide extensive benefit to ecological function through removal of overwater structures or restoration of nearshore habitat. Appendix B shows the range of Restoration Need scores by Salmon Priority Area. Section 4.2 examines these scores in association with the Conservation Priority scores and provides some discussion of how interpretation of the two scoring frameworks could give guidance for restoration or conservation decisions.

Table 9. Restoration Need Scores by Salmon Priority Area

		Salmon Priority Area		
		Area 1	Area 2	Area 3
Restoration Priority	High (27-50)	123	279	146
	Moderate (12-26)	825	1,522	331
	Low (0-11)	810	1,988	668

4.2 Overall Prioritization Outputs

To identify priority tiers, we used Jenks natural breaks classification method to determine the best arrangement of data values into 3 distinct classes (see Figure 4-6, Table 9). For conservation prioritization scores this creates ranges of 0 to 29 points for Low, 30 to 44 points for Moderate and 45 to 87 points for High. While most shoreline parcels contribute to the ecological processes in WRIA 6, the contributions of these parcels were characterized on a spectrum from High to Low across the 3 categories of sites. The number of parcels, the area of those parcels and the length of shoreline contained within those parcels is identified in Table 10. Prioritization breaks were performed by parcel, and the largest amount of shoreline length is in the Moderate category. The least amount of shoreline length is in the parcels that scored the lowest for ecological value.

Table 10. Conservation Prioritization Scores by Salmon Priority Area

	Area 1			Area 2			Area 3			Totals		
Priority Tier	Parcels (count)	Parcel Area (acres)	Shore-line Length (ft)	Parcels (count)	Parcel Area (acres)	Shore-line Length (ft)	Parcels (count)	Parcel Area (acres)	Shore-line Length (ft)	Parcels (count)	Parcel Area (acres)	Shore-line Length (ft)
High	917	1,874.6	155,769	875	3,901.6	210,118	20	563.3	11,030	1,812	6,339.5	376,917
Moderate	784	591.9	65,250	2,157	2,330.2	247,600	393	1,421.1	88,768	3,334	4,343.2	401,618
Low	72	34.5	5,351	765	344.2	59,942	739	354.3	59,280	1,576	733	124,573

For comparison of the size of each Salmon Priority Area to the prioritization assignments in Table 10, the number of parcels, area, and shoreline length in each Salmon Priority Area is presented in Table 11. As intended with the scoring framework, it reflects the geographic priorities that WRIA 6 has established in identifying three tiers of Salmon Priority Areas. While Area 1 contains only 26% of the WRIA's parcels, the area has 51% of the high priority conservation parcels. Similarly, for parcel area, Area 1 contains only 22% of the WRIA's total area, but 30% of the high priority conservation area. Looking at Area 3, that area has fewer high priority areas compared to its overall percentage distributions in the WRIA.

Table 11. Summary of Parcels and Size of Each Salmon Priority Area

Priority Tier	Area 1	Area 2	Area 3	Total
Parcels (count)	1,773	3,797	1,152	6,722
Parcel Area (Acres)	2,501	6,576	2,339	11,416
Shoreline Length (ft)	226,370	517,660	159,078	903,108

In considering salmon habitat, ecological function can be enhanced in projects where restoration actions can improve habitat conditions. Table 12 indicates the relationship between site conservation and restoration scores. Relatively few sites score high for both conservation and restoration opportunities (70 parcels). Larger number of sites have moderate restoration opportunities. The large majority of high priority conservation parcels have low restoration priority, indicating these sites have few of the modifications included in the analysis.

Table 12. Conservation Prioritization Scores vs. Restoration Prioritization Scores

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="3">Conservation Priority</th></tr>
<tr><th>High</th><th>Moderate</th><th>Low</th></tr>
<tr><th rowspan="3">Restoration Priority</th><th>High</th><td>85</td><td>223</td><td>247</td></tr>
<tr><th>Moderate</th><td>581</td><td>1,370</td><td>743</td></tr>
<tr><th>Low</th><td>1,150</td><td>1,745</td><td>587</td></tr>
</table>

5.0 SUMMARY

The intended use of this prioritization is for conservation and restoration practitioners to consider when identifying acquisition opportunities in WRIA 6. When a project is proposed for an individual parcel it can be reviewed against these criteria and updated site-specific information can be added to refine or update the prioritization. This prioritization method may not fully account for conservation proposals that may encompass multiple parcels; in considering an individual parcel's score, there is utility in considering the scores assigned to adjacent parcels. Errors of omission or commission may occur within source datasets, and local site conditions may change between the time of data collection and project proposals.

The data distribution does not appear to create clear breaks or segmentation between target and non-target parcels for conservation. Instead, scores indicate that parcels with higher scores are likely to contribute greater conservation value than parcels with lower scores. Methods may not fully account for parcel size and shoreline length. Therefore, when individual parcels are evaluated, site-specific considerations including parcel size, shoreline length and geographic context may be important.

Based on the current prioritization framework, sites in areas 1 and 2 may score similarly, while parcels in area 3 have much lower prioritization scores on average.

Identification of parcels as providing high ecological function and/or restoration potential does not indicate whether the site can be protected or whether ecological functions could be improved through restoration. It is anticipated that future efforts may assess these characteristics on a site-by-site basis as part of a feasibility evaluation of priority sites.

It may happen in the future that an opportunity for acquisition of multiple parcels would arise. In this case, the prioritization framework could provide a basis for assessment of the conservation or restoration potential of the group of parcels. However, the decision would require knowledge of the local context and connection between the parcels, as the scoring may differ between the parcels within the group. This framework was built using parcels as the unit of analysis but could be used to assess larger units with the necessary contextual knowledge.

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Appendix A

Excerpt of Scores for Parcels in High Tier for Overall Prioritization

ParcelNo	Landscape Context_Score	Ecosystem Processes_Score	Habitat Function_Score	Restoration Potential_Score	Overall Prioritization Score
R33217-460-2020	21	46	20	17	87
S8133-00-0000C-0	12	49	18	2	79
R32810-096-4580	11	46	20	15	77
R13230-332-3560	7	50	18	14	75
S7780-00-0000A-0	22	32	18	0	72
S8413-00-0000A-0	19	33	18	15	70
S8240-02-00013-0	17	35	18	0	70
S7730-02-0000B-0	14	42	12	9	68
S6250-00-0000C-0	18	38	12	20	68
R33106-370-1850	19	47	2	19	68
S8240-02-00010-0	17	32	18	15	67
S8240-00-00017-0	18	31	18	0	67
R33131-237-2390	11	38	18	0	67
R23432-431-0320	18	31	18	0	67
S8240-02-00011-0	16	32	18	5	66
S8240-00-00014-0	17	31	18	0	66
S7385-00-00006-0	16	42	8	0	66
S7185-00-00005-0	17	31	18	0	66
S7185-00-00004-0	17	31	18	0	66
R33229-065-1630	21	31	14	0	66
R23308-508-2040	21	25	20	12	66
S8240-00-00015-0	16	31	18	0	65
S7185-00-00008-1	20	27	18	14	65
R32811-320-1660	12	45	8	21	65
R23432-426-0470	17	30	18	4	65
R23305-277-2720	18	29	18	0	65
R23223-496-2930	19	28	18	0	65
	18	29	18	36	65
S8355-03-00031-0	17	29	18	10	64
S8240-02-00012-0	17	29	18	10	64
S7385-00-00011-0	18	38	8	4	64
S7185-00-00006-1	15	31	18	0	64
R33229-346-3180	22	34	8	0	64
R33217-348-1260	19	25	20	2	64
R33004-290-4630	18	28	18	15	64
R33004-280-4520	18	28	18	10	64
R32811-119-1680	12	38	14	19	64
R23336-244-0160	21	25	18	0	64
R23305-515-1850	18	28	18	0	64
R23120-050-4570	8	38	18	4	64

	19	31	14	32	64
	19	31	14	32	64
S7755-00-06020-0	16	29	18	4	63
R33217-408-0980	18	31	14	6	63
R33217-347-1470	18	25	20	0	63
R33217-346-1620	18	25	20	0	63
R32918-070-1100	12	45	6	31	63
R23222-036-4550	9	36	18	0	63
R13230-075-2870	9	42	12	17	63
	16	29	18	21	63
	16	29	18	21	63
S8345-00-16009-0	15	27	20	15	62
S8240-02-00009-0	16	28	18	15	62
S8240-02-00008-0	16	28	18	15	62
S7525-02-00074-0	20	24	18	14	62
R33129-332-0550	17	27	18	0	62
R33025-370-4600	19	25	18	0	62
R33004-293-4450	18	26	18	0	62
R23336-394-0140	22	22	18	0	62
R23335-067-5020	18	26	18	2	62
R23335-049-4860	18	26	18	6	62
R23335-018-4560	18	26	18	14	62
R23322-272-2330	20	30	12	0	62
R23203-021-2130	18	26	18	6	62
R23202-510-4880	18	26	18	0	62
R23202-500-4830	18	26	18	2	62
R23107-424-3953	13	31	18	10	62
S7525-02-00072-0	19	24	18	19	61
S7185-00-00007-1	15	28	18	19	61
S7185-00-00006-2	16	27	18	18	61
R33227-302-5010	23	30	8	19	61
R33217-346-1810	19	22	20	0	61
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S8330-00-00001-2	16	17	12	23	45
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R32913-426-0730	8	25	12	0	45
R32912-240-0400	8	25	12	15	45
R32901-004-0550	5	28	12	21	45
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R32814-152-1020	5	26	14	11	45
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R23223-500-3290	17	16	12	4	45
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R23027-440-0720	8	25	12	6	45
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R23021-478-3810	6	21	18	4	45
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R13231-320-4660	6	27	12	10	45
R13231-240-5200	8	25	12	0	45
R13221-074-4740	7	26	12	21	45
R13221-025-3670	6	21	18	10	45
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	6	27	12	21	45
	6	27	12	21	45
	6	27	12	26	45
	6	27	12	26	45
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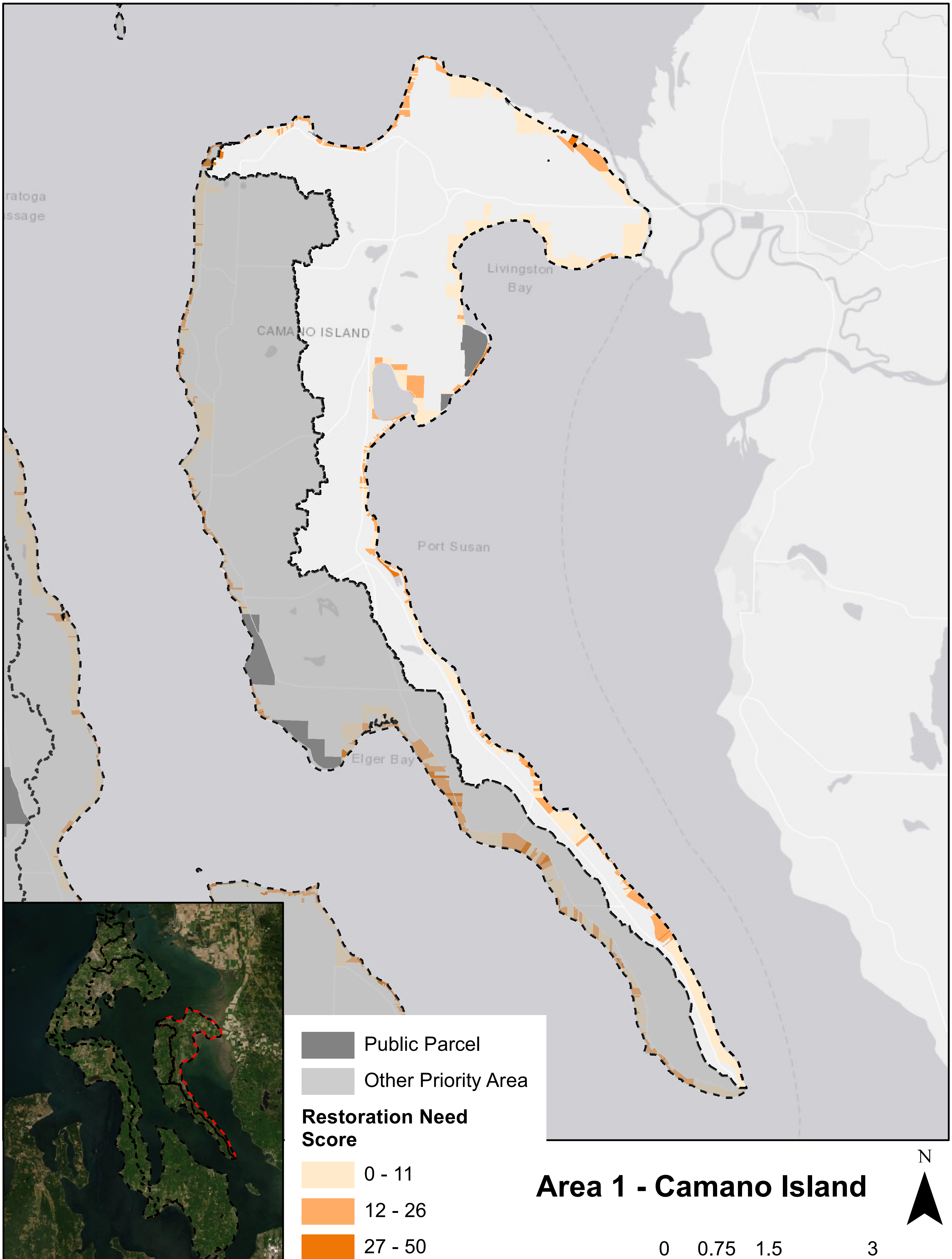
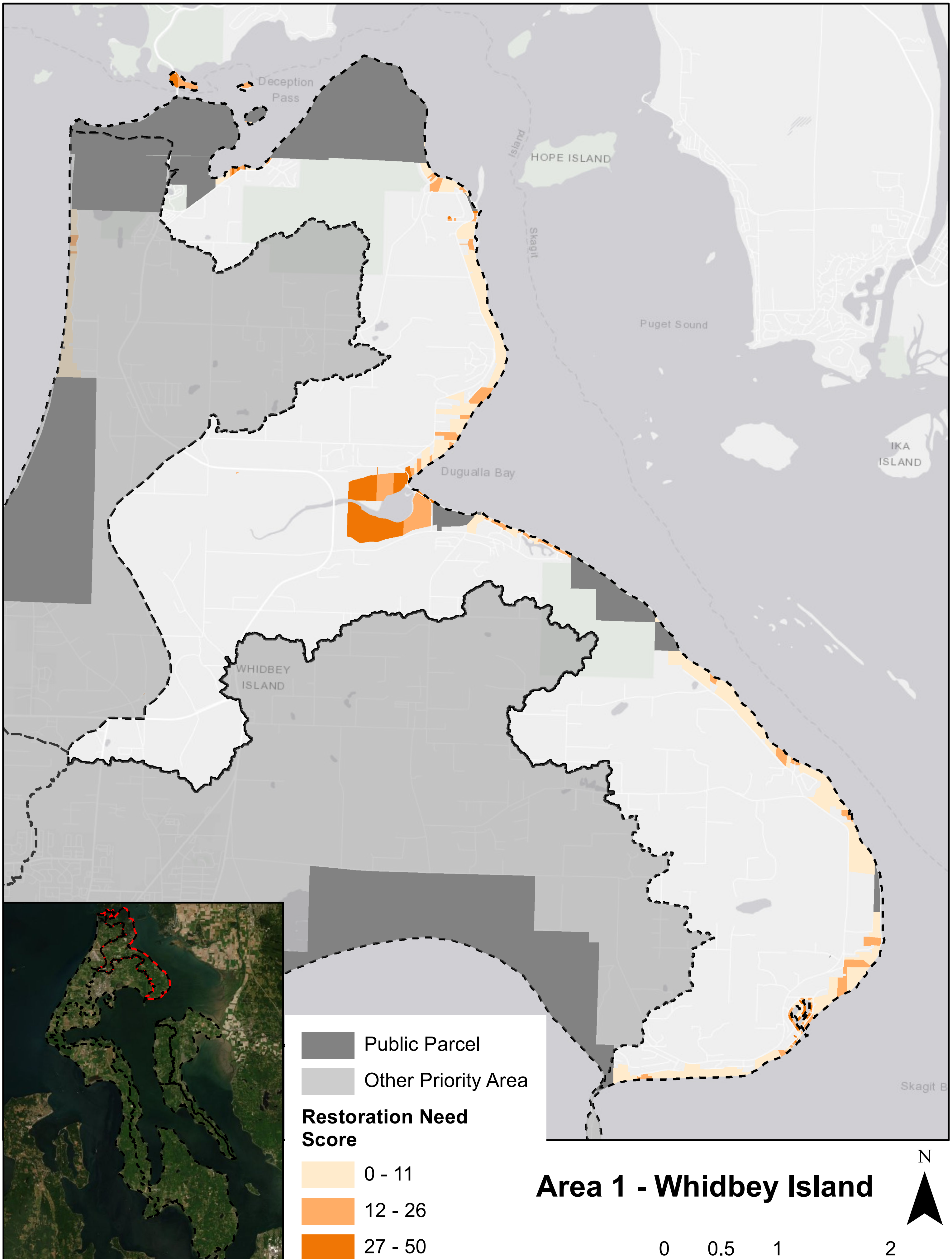
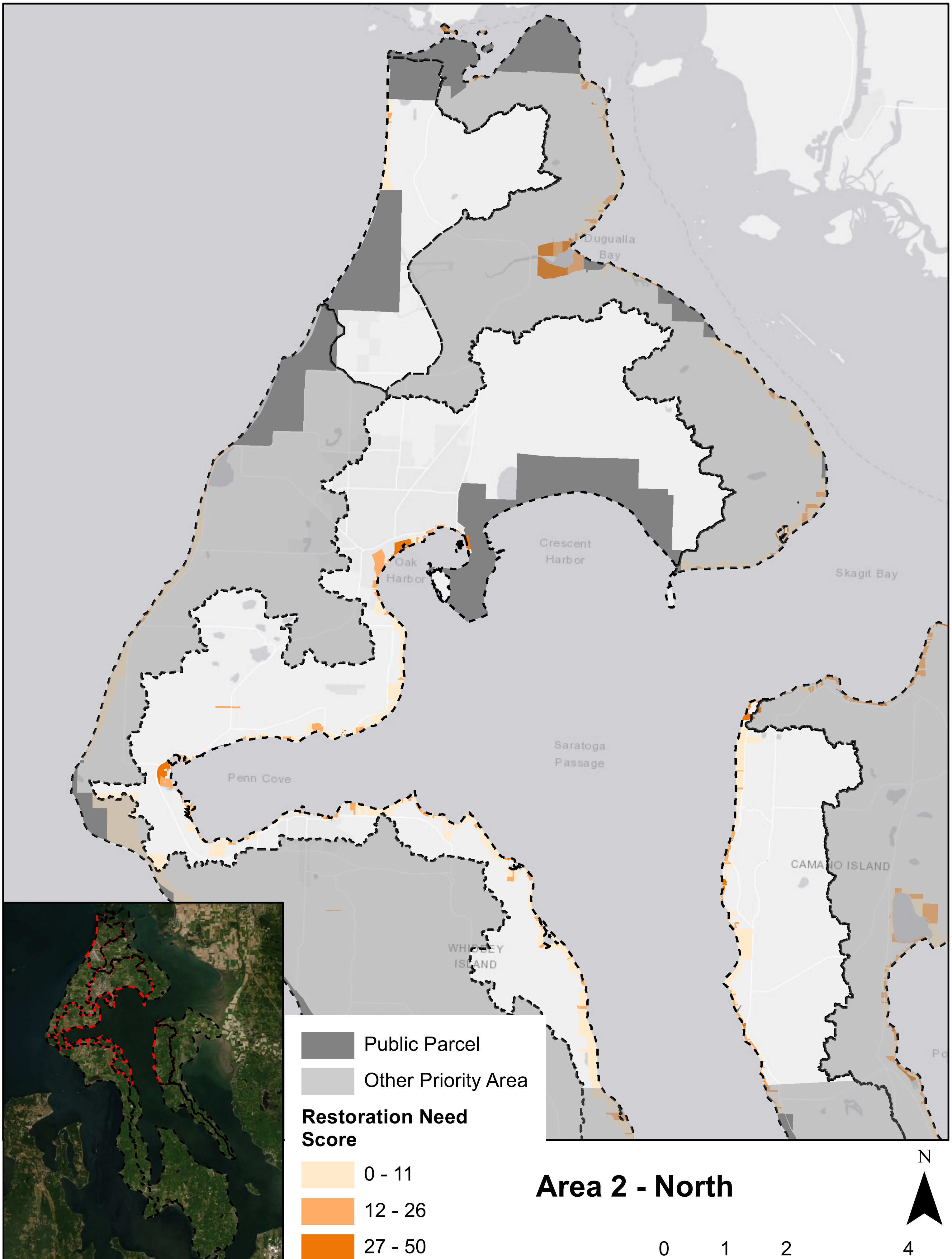
Appendix B
Restoration Need Prioritization Score Maps



Area 1 - Camano Island

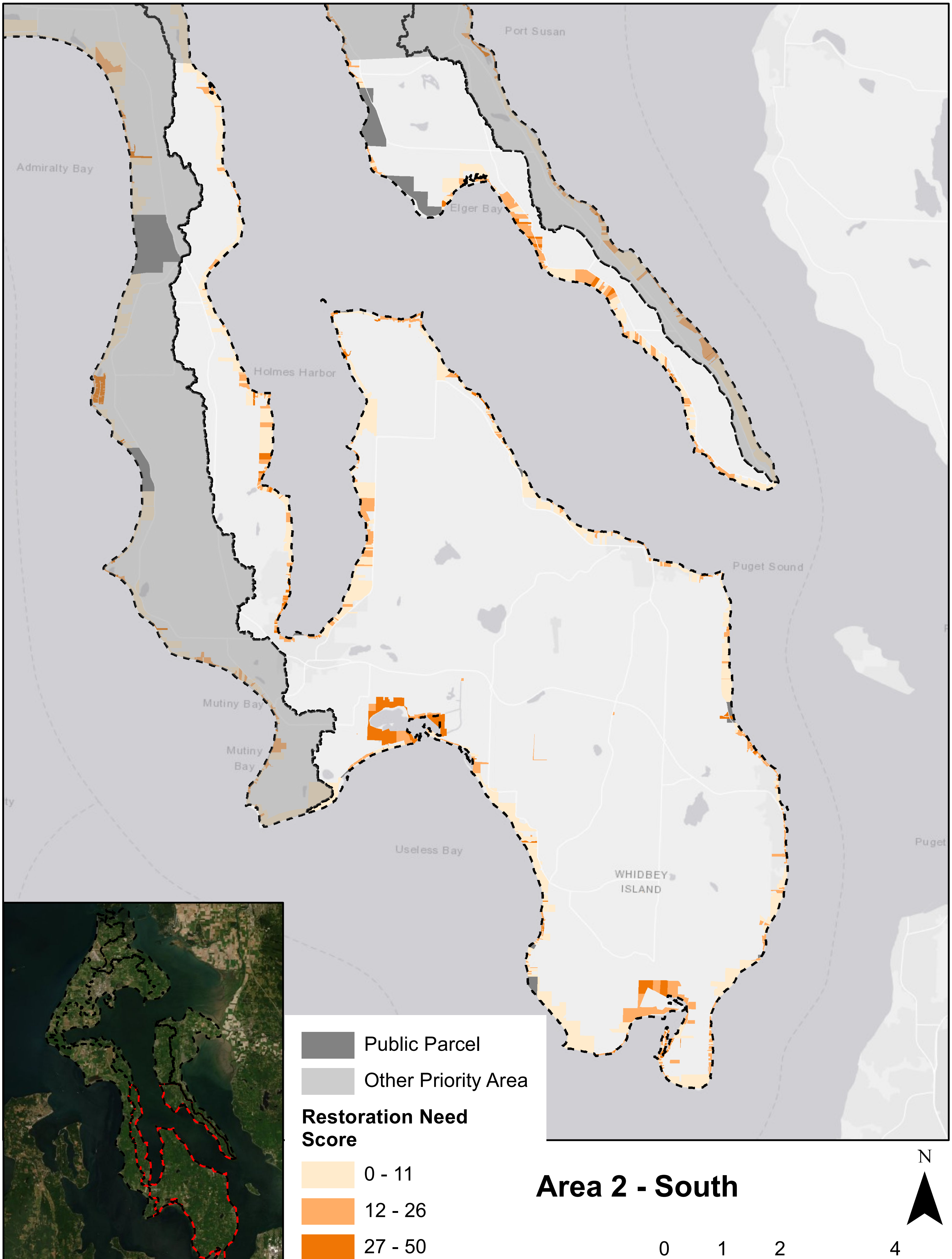


Area 1 - Whidbey Island

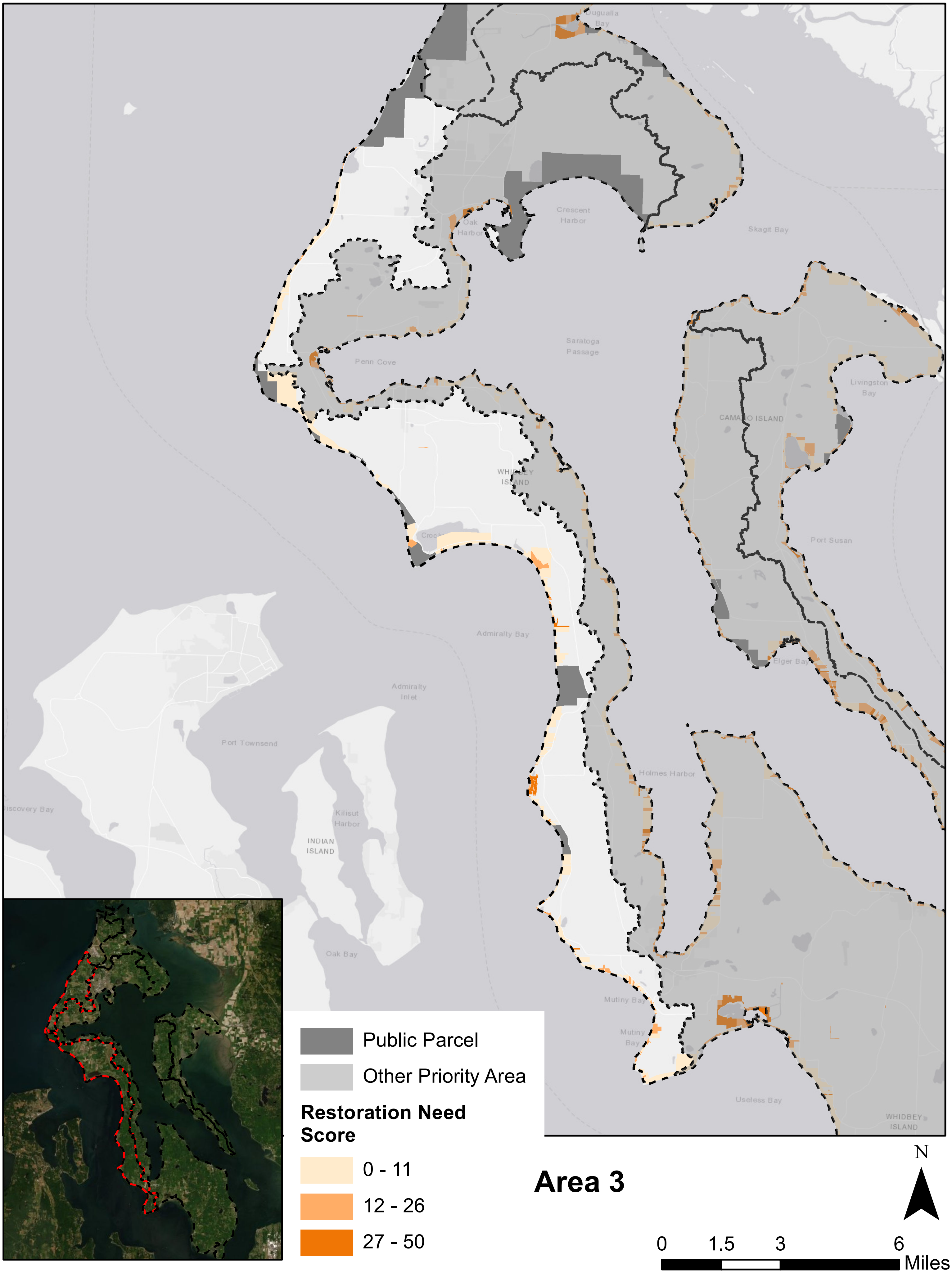


Dugualla Bay
Crescent Harbor
Oak Harbor
Skagit Bay
Saratoga Passage
Penn Cove
CAMANO ISLAND
WHIDBEY ISLAND
Public Parcel
Other Priority Area
Restoration Need Score
0 - 11
12 - 26
27 - 50
N
0
1
2
4
Miles

Area 2 - North



Port Susan
Admiralty Bay
Elger Bay
Holmes Harbor
Puget Sound
Mutiny Bay
Mutiny Bay
Useless Bay
WHIDBEY ISLAND
Puget
Public Parcel
Other Priority Area
Restoration Need Score
0 - 11
12 - 26
27 - 50
Area 2 - South
N
0
1
2
4
Miles


Dugualla Bay
Crescent Harbor
Oak Harbor
Skagit Bay
Saratoga Passage
Penn Cove
Livingston Bay
CAMANO ISLAND
WHIDBEY ISLAND
Port Susan
Admiralty Bay
Admiralty Inlet
Elger Bay
Port Townsend
Holmes Harbor
Kilisut Harbor
INDIAN ISLAND
Oak Bay
Mutiny Bay
Useless Bay
WHIDBEY ISLAND
Public Parcel
Other Priority Area
Restoration Need Score
0 - 11
12 - 26
27 - 50
Area 3
N
0
1.5
3
6
Miles

CONFLUENCE
ENVIRONMENTAL COMPANY