GIS Land Cover Baseline Study for Three Estuaries: Snow/Salmon, Quilcene and Duckabush

Final Project Technical Report

Prepared by

Jhanek Szypulski and Cynthia Rossi

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Point No Point Treaty Council

19472 Powder Hill Place NE, Suite 210

Poulsbo, Washington 98370

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Title

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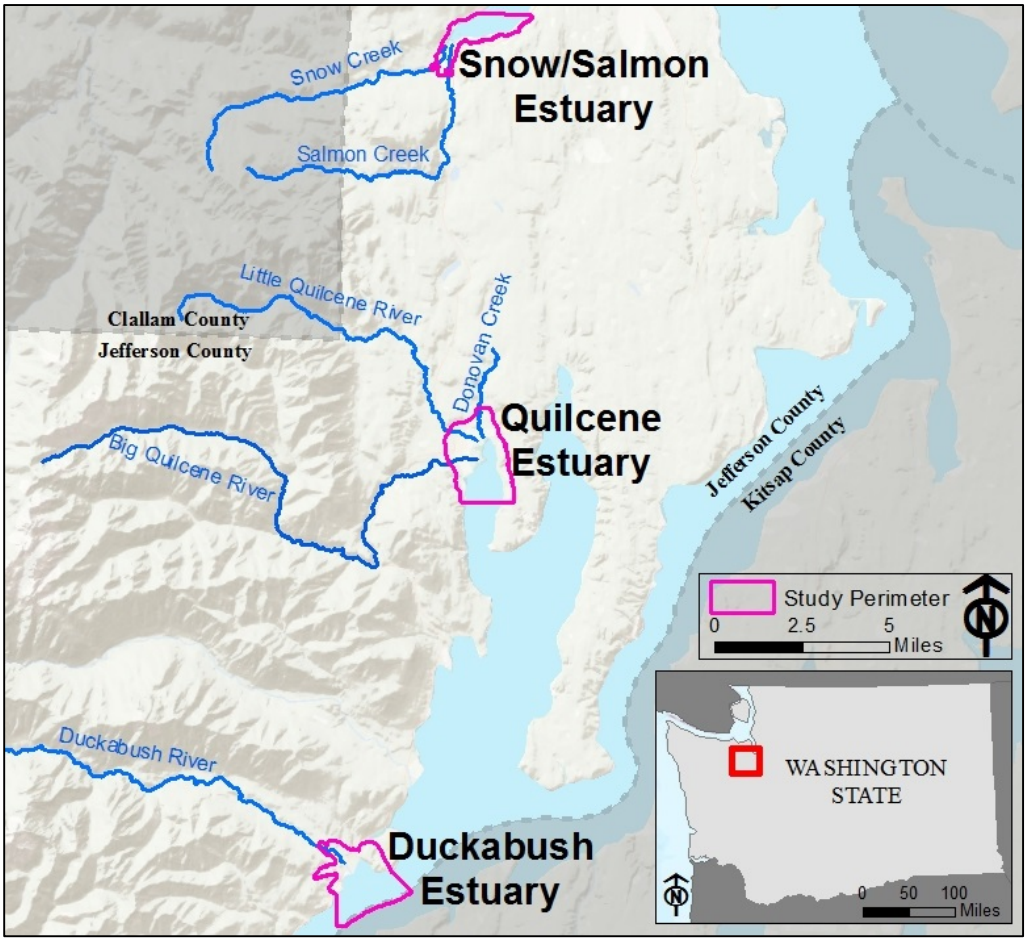
Introduction

During the course of the Point No Point Treaty Council's (PNPTC) FY2016 Climate Change Adaptation Initiative, the PNPTC staff were able to create comprehensive estuary land cover maps and associated geodatabases for three primary estuaries in northwest Washington (Snow/Salmon, Quilcene and Duckabush) (Figure 1).

Figure 1: Estuary Study Areas: Snow/Salmon, Quilcene, and Duckabush.



Estuaries are among the most biologically productive environments in the world. With climate projections showing significant warming temperatures throughout the 21st century (*Stocker et. al., 2013*), understanding of estuary structure, function, and vulnerabilities, is both ecologically and economically indispensable to residents in this region. The S'Klallam Tribes are concerned that the direct deleterious effects of climate change which include higher water temperatures, changes in seasonal flows, and altered inputs of fresh water, contaminants, and sediment, coupled with the secondary effects of human activities, such as shoreline armoring, deforestation, and urbanization will jeopardize the sustainability of vital natural resources such as salmon and shellfish (*Lawler, 2007*).

PNPTC has completed its objective for this grant which included an up-to-date estuary delineation (2015) of the Snow/Salmon, Duckabush, and Quilcene estuaries. Using NAIP high resolution data from 2015, GIS delineations were developed into detailed estuarine and land cover maps for these areas. These estuaries were selected due to their importance as shellfish harvest sites and ESA listed fish habitat, and were small enough to be studied in detail. Additionally, their geographic distribution will allow for a unique opportunity to compare the state of three different estuaries, each influenced by different geomorphic conditions, for future studies. The land cover in these three watershed areas range from intermittent second growth forest to interspersed development. Coastal modifications, including rip-rap, bulkheads, and roadways, are present within or nearby each of the three estuaries to varying degrees.

Methods

The study areas were based on historic studies that the PNPTC has undertaken in these estuary areas. Some of these species are ESA listed, and these areas play a critical role in the development of many salmonids and shellfish species important to the Tribes. One-meter resolution NAIP (National Agricultural Imagery Program) imagery was retrieved from the United States Department of Agriculture (USDA) for 2015. This imagery was uploaded into ArcMap (*ESRI, 2018)* and clipped to the areas of interest for the Point No Point member tribes. Complete digitization of each estuary into polygons was conducted at 1:2,500 extent. Each estuary was then delineated into the categories found in Table 1 below, and an updated land cover map was created. Supplementary data for land cover classes were retrieved from NOAA's National Shoreline 2016 data for mean higher high water (MHHW) mark, Washington State Department of Natural Resources' 2017 data for mean lower low water (MLLW) mark, and from Washington State Department of Agriculture's 2017 data for agricultural lands. These data were quality assessed and quality controlled through a systematic approach.

Table 1. Estuary Baseline Land Cover Classes.

Land Cover	Definition
1. Agriculture	Land defined as agricultural use by the Washington State Department of Agriculture as of 12/31/2017.
2. Beach	Shore areas along coastal waters.
3. Canopy	Areas covered by adult tree cover canopy as seen through aerial imagery.
4. Coastal Lagoon	Small pools located above the MHHW mark and bordering the coast.
5. Developed	Land that has been built upon or developed, excluding roads.
6. Grass/Shrubland	Land covered with grasses or shrubs.
7. Intertidal	Areas that lie between the MLLW and MHHW marks.
8. Irrigation	Irrigated canals.
9. River Banks	Shore areas along freshwater rivers and streams.
10. River/Tributary	Rivers and tributaries above the MHHW mark.
11. Road	Areas that are impervious and are considered roads or land transportation routes.
12. Saltwater Vegetation	Marsh grasses and other vegetation located in tidally affected marine areas.
13. Subtidal	Areas below the MLLW mark.

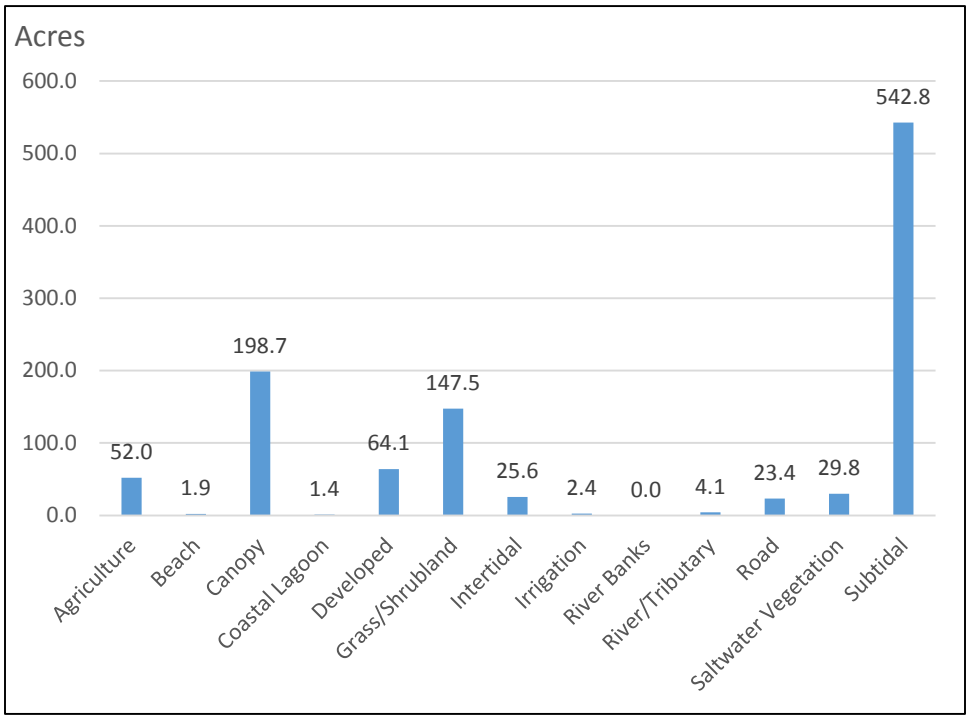
Results

Snow/Salmon Estuary

The Snow Creek/Salmon Creek estuary is a stream-delta habitat complex located at the head of Discovery Bay. The study area, outlined in pink at the top of Figure 1, is 1,093.45 acres and is the largest habitat complex in the Discovery Bay area. The estuary is bordered to the east/south by WA State Highway 20 and to the west/north by US Highway 101, which bisects historic marsh habitat. In addition, there is agricultural development immediately bordering US 101 and extending to the south. There is relatively little commercial development within this study area. However, there are numerous residential properties to the north and south sides of the estuary including properties bordering the shoreline and containing private docks.

The Snow/Salmon estuary is severely impaired. It is estimated that two hectares of tidal wetlands were lost in the Snow/Salmon estuary between 1870 and 2006. The first major anthropogenic modification to this area was around 1900 when the Snow Creek was diverted out of the Salmon Creek. At approximately the same time, a railroad was built and significant areas of tidal flats were filled in, which displaced tidal marsh as well. The development of the tidal flat in the Snow/Salmon estuary increased channelization of the creeks, greatly reducing tidal exchange and channel connectivity which led to rapidly increased rates of delta progradation. While the overall loss of tidal wetlands in the Snow/Salmon estuary is moderate, the spatial distribution of the study area has changed dramatically. The most significant change to the Snow/Salmon estuary is the substantial conversion of tidal flat to tidal marsh (2.5 ha), resulting from channel diversion and in-fill development. (*Todd et al., 2006)*

Table 2. Snow/Salmon Estuary Study Area Land Class Acreage.

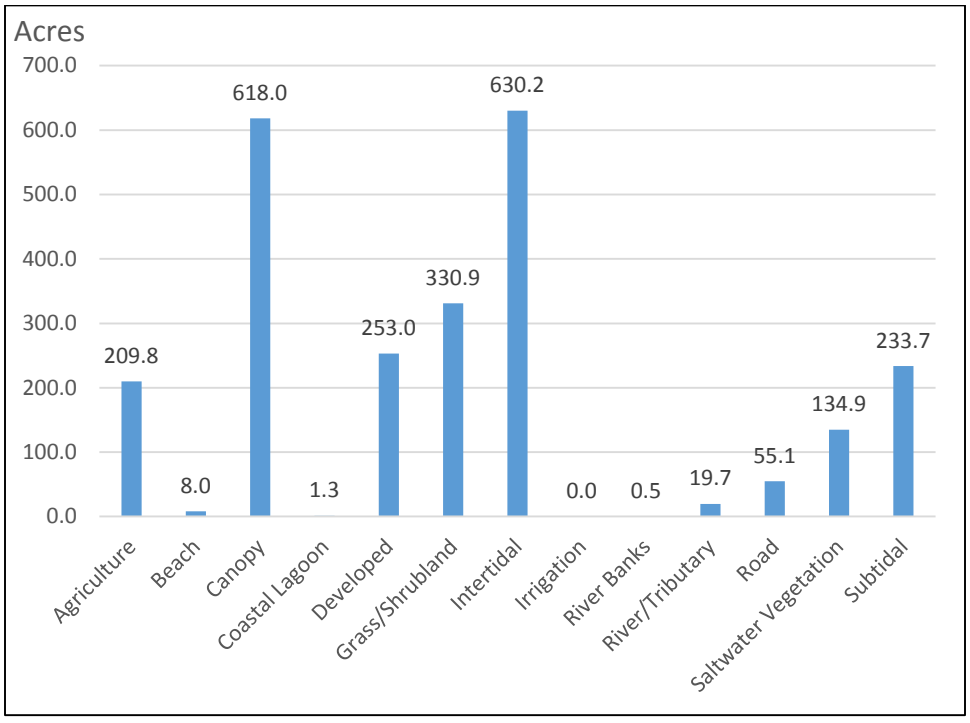


Quilcene Estuary

The Quilcene estuary, at the northwest tip of Dabob Bay, is a stream-delta habitat complex with freshwater inputs from the Big Quilcene River, the Little Quilcene River, and Donovan Creek. The study area, outlined in pink at the center of Figure 1, is 2,495.21 acres. This estuary has one of the most extensive tidal flats in the Hood Canal area. East Quilcene Road borders the eastern edge of the estuary, crosses the mouth of Donovan Creek, and traces the northern side of the Little Quilcene River through the town of Quilcene. US 101 borders the Little Quilcene River further upstream as well as The Big Quilcene River within the study area.

By 1883, much of the land bordering the Quilcene estuary was already developed with roads and cleared forests for pasture. This is still seen today with agricultural, commercial, and residential development in the town of Quilcene. The estuary has seen significant changes since settlement began including extensive diking in the tidal marsh, tidal marsh converted to pasture, riverbank armoring, and channelization of a former "web of wide tidal channels." Donovan Creek was completely disconnected from portions of its tidal marsh with the construction of the East Quilcene Road culvert. However, the culvert was replaced with a concrete bridge in 2007 which allows more natural estuarine processes to occur. Approximately twelve acres of tidal flat has been filled or drained in the Quilcene estuary and an additional sixty acres of tidal flat has been replaced by tidal marsh since 1883 resulting from dramatically increased rates of delta progradation. Because of these factors, the rivers have lost their connectivity with the wetlands and the estuary is considered moderately impaired. (*Todd et al., 2006*)

Table 3. Quilcene Estuary Study Area Land Class Acreage.

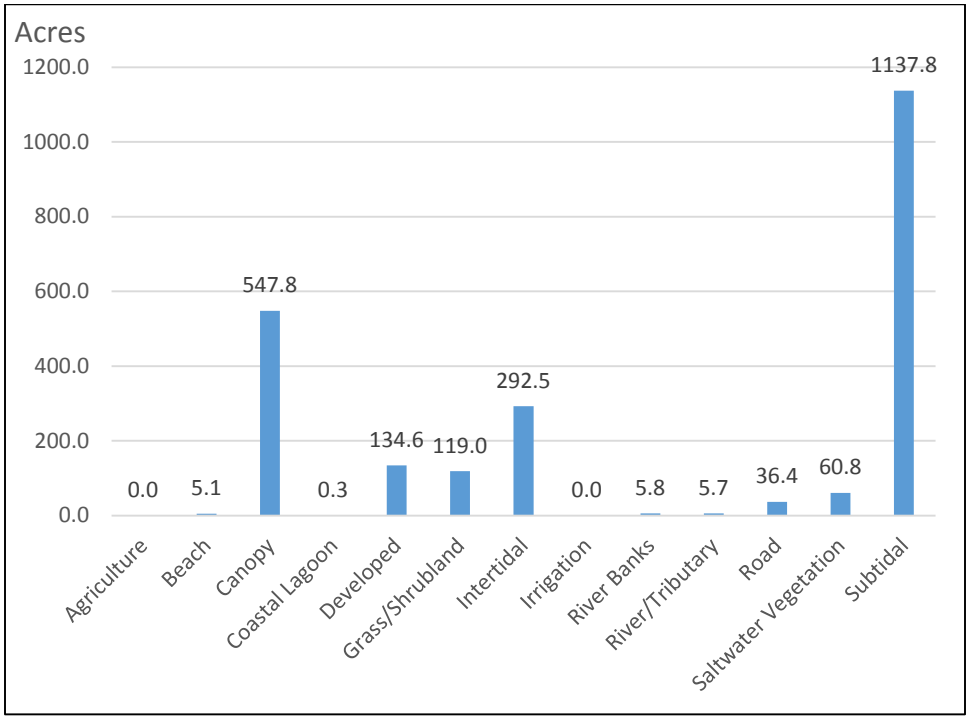


Duckabush Estuary

The Duckabush estuary is a stream-delta habitat complex located on the western side of Hood Canal, just south of Brinnon, WA. The study area, outlined in pink at the bottom of Figure 1, is 2,345.72 acres. The Duckabush River is the main freshwater input, however, historical records show there was at least one other river fork emptying into the bay in 1871. The northern fork was completely disconnected from the current main channel by 1957 due to the construction of US 101, in 1939, which crosses through the middle of the estuary. Although there is no agriculture in the area, there are many residential properties including many bordering the Canal, and several with private docks.

By 1883, there were already modifications of the estuarine area including land clearing and fencing for orchards and pastures on lands bordering the river. Similar to the other estuaries in this study, the Duckabush has experienced rapid delta progradation resulting in the conversion of tidal flat to tidal marsh. Coupled with extensive diking, shore armoring, dredging, large woody debris removal, and channelization of the river (mainly due to US 101 construction), the estuary has lost much of its historic connectivity. Much of the tidal marsh that was disconnected from the natural estuarine processes has been converted into shrub land. The Duckabush estuary habitat complex is considered moderately impaired. (*Todd et al., 2006*)

Table 4. Duckabush Estuary Study Area Land Class Acreage.



Conclusions/Discussion

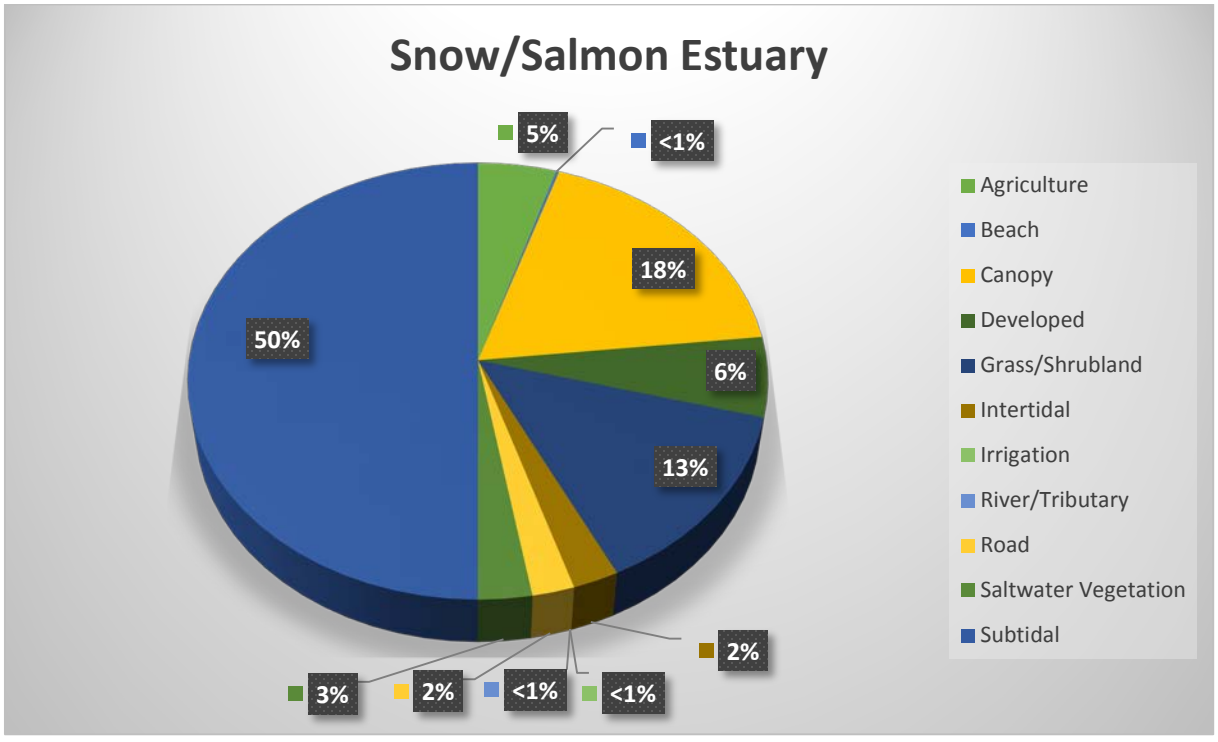
The purpose of this data is to get an up-to-date land cover layer that can be compared to historic data (Todd et al, 2006) and also to be used in the SLAMM (Sea Level Affecting Marshes Model) (PNPTC

Technical Report 19-03) for more accurate results. Results from the SLAMM model will be discussed in the SLAMM Final Report separately in the PNPTC Technical Report 19-03. These base maps serve as a comparable baseline for future studies. Using successive, or pre-cursive, years of satellite imagery, change over time analyses can be conducted to determine significant changes in the spatial distribution of the land cover types within these estuaries.

Additionally, the end goals for this data are three-fold: 1) To locate critical areas for salmonid rearing and spawning, and places that form refugia for them in these estuaries; 2) To locate change areas that may affect shellfish beaches located within the estuarine beaches; and, 3) To use this high resolution classified data in the SLAMM model in order to get a better picture of where change from the different land cover categories might occur. This is phase one of an on-going study. Below is a description of the overall percentage area of each land cover category.

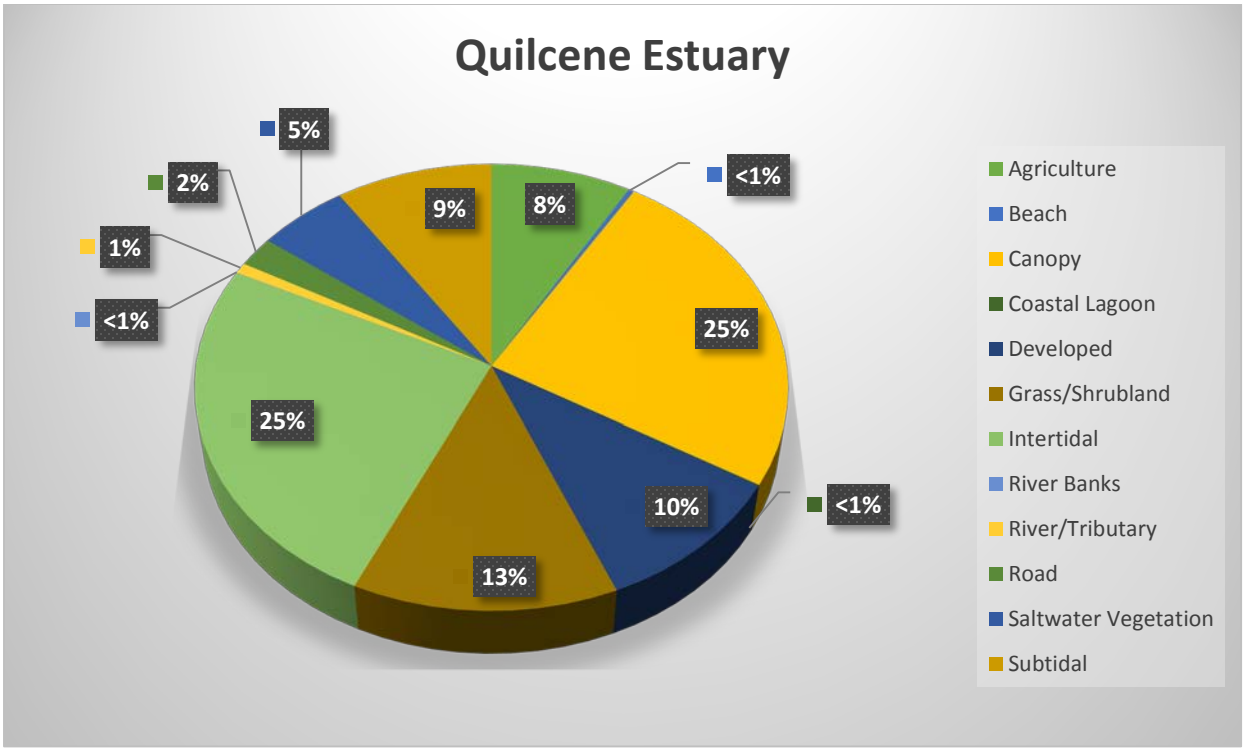
Snow/Salmon Estuary:

Based on the results of the 2015 GIS delineations, approximately 50% of the focus area is subtidal, 18% is canopy, 13% is grass/shrubland, 6% is developed, 5% is agriculture, 3% is saltwater vegetation, 2% is intertidal, 2% is roads, <1 % is coastal lagoons, <1% is irrigation, and <1% is river/tributaries. The dominant categories are subtidal, canopy, and grass/shrubland. Of particular interest for the tribes are the non-developed areas and beaches, coastal lagoons, river banks, river mainstems, and saltwater vegetation. As mentioned above, this is phase 1 of a larger project. As a next step, a comparison of overall area from 1800, 2006 & 2015 can be undertaken to see where the biggest changes will occur.



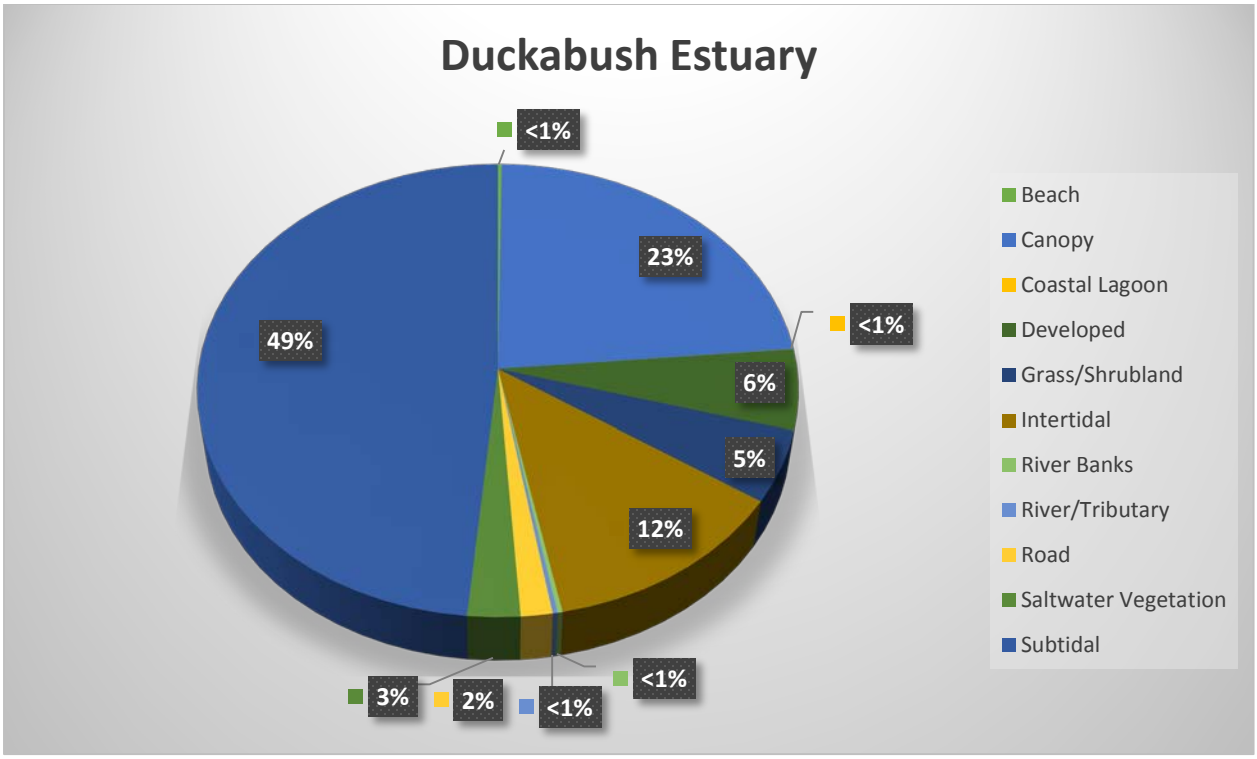
Quilcene Estuary:

Based on the results of the 2015 GIS delineations, approximately 25% of the area is canopy, 25% is subtidal, 13% is grass/shrubland, 10% is developed, 9% is subtidal, 8% is agriculture, 5% is saltwater vegetation, 2% is roads, 1% is river/tributaries, <1% is beach, <1% is coastal lagoons, and <1% is river banks. The dominant categories are canopy, subtidal, and grass/shrubland. Of particular interest for the tribes are the non-developed areas and beaches, coastal lagoons, river banks, river mainstems, and saltwater vegetation.



Duckabush Estuary:

Based on the results of the 2015 GIS delineations, approximately 49% of the area is subtidal, 23% is canopy, 12% is intertidal, 6% is developed, 5% is grass/shrubland, 3% is saltwater vegetation, 2% is roads, <1% is beach, <1% is coastal lagoons, <1% is river banks, and <1% is river/tributaries. The dominant categories are subtidal, canopy, and intertidal. Of particular interest for the tribes are the non-developed areas and beaches, coastal lagoons, river banks, river mainstems, and saltwater vegetation.



This data and report was produced by the Point No Point Treaty Council. For more information, please contact the PNPTC through their website at www.pnptc.org.

Appendices

Snow/Salmon Estuary……..……....…..…. Appendix A
Quilcene Estuary…….……..……. Appendix B
Duckabush Estuary…….…… .Appendix C

CITATIONS

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