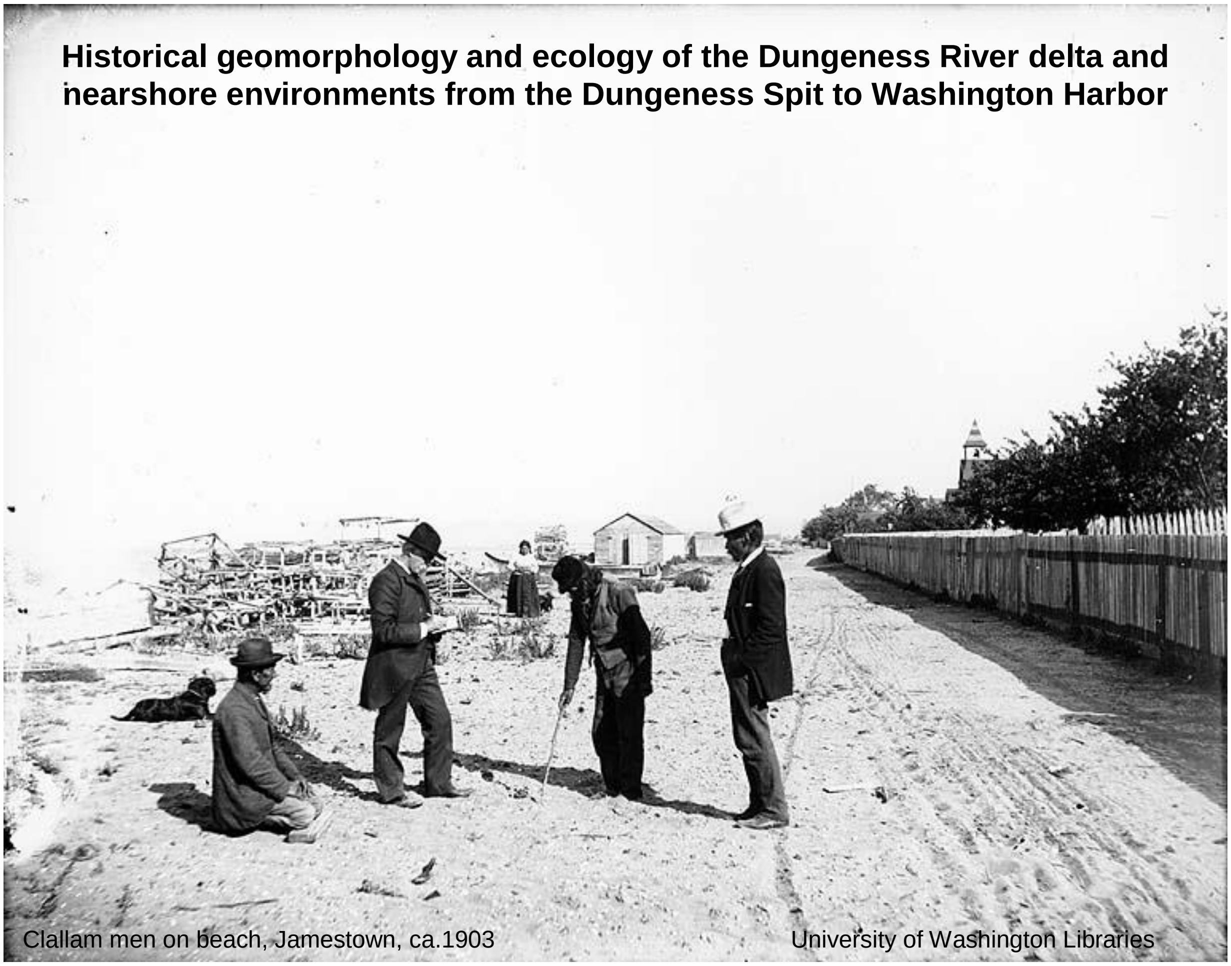
Historical geomorphology and ecology of the Dungeness River delta and nearshore environments from the Dungeness Spit to Washington Harbor



Clallam men on beach, Jamestown, ca.1903 University of Washington Libraries

Report prepared for:

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SUMMARY

This study was undertaken for the Jamestown S'Klallam Tribe to provide information in support of efforts to restore the lower Dungeness River, it's delta, and adjacent nearshore. The study makes use of cross-referencing methods and sources, including historical maps, aerial photographs, field notes, and other documents along with a high-resolution digital elevation model from lidar in a geographic information system (GIS) and geomorphic and ecological interpretation to describe the physical and ecological landscape, and landscape processes, at the time of first settlement in 1851. It also describes changes to those environments up to the beginning of the 21st century.

An understanding of the landscape's evolution since deglaciation approximately 12,000 years ago provides context for understanding historical (mid 1800s) and current environments. The Dungeness River created and successively incised into and abandoned three paleochannels (referred to here as "Dungeness River paleochannels," and abbreviated "DRP"s), in the present-day Bell Creek, Gierin Creek, and Casselary Creek valleys. Different landforms and habitats now exist where each DRP meets the Strait of Juan de Fuca, potentially reflecting differences in nearshore bathymetry, Holocene (post-glacial) sea level rise, and the relative duration of the Dungeness River's occupation of each paleochannel. The Bell Creek paleochannel terminates in an estuary (Washington Harbor), the Gierin Creek paleochannel terminates in an extensive saltmarsh (Graysmarsh), and the Casselary Creek paleochannel terminates in a large alluvial fan built onto a coastal plain that extends roughly from the Dungeness Spit to near Jamestown. The modern Dungeness River is also building a large fan from its valley onto the coastal plain that nearly coalesces with the Casselary Creek paleochannel fan. Most recently, several lines of evidence suggest that the Dungeness River took a different path on its fan to Dungeness Bay, creating a delta in the area of modern Meadowbrook Creek, potentially until only a few hundred years before the mid 1800s. The asymmetry of the Dungeness River fan to the southeast suggests that the river has occupied the area of the modern Dungeness River delta for only a short period.

In the reconstructed mid-19th century landscape, the Dungeness River delta was located to the east of its present location, had a significant amount of associated saltmarsh, and longshore transport created a eastward-accreting sand spit at the delta's outer margin. A similar delta existed in the Meadowbrook Creek area, including an estuary having a complex assemblage of habitats create by saltmarsh, lagoons, channels, and a sand spit. The coastal plain to the southeast of the Meadowbrook Creek delta included large freshwater wetlands and bottomlands of deciduous brush and forest; the wetlands extended inland in the lower-lying land between the two large alluvial fans. Farther to the southeast, Graysmarsh was the largest saltmarsh in the greater Dungeness River area. Each of the three Dungeness River paleochannels (the Bell Creek, Gierin Creek and Casselary Creek paleochannels) included cedar swamps where the valleys narrowed. The Sequim Prairie, up-valley of these paleochannels on a large expanse of older alluvium, included two large fir-oak woodland inclusions, and graded into wetland at its eastern margin in the Bell Creek paleochannel valley. Substantial prairies also existed on the higher-elevation surfaces on glacial sediments. The General Land Office field notes indicate that small-diameter Douglas fir was overwhelmingly the most common tree in the greater Dungeness River area forests, and that the substantially less common western redcedar was typically much larger in diameter than Douglas fir.

By 1870, the Dungeness River had abandoned the delta shown on the earliest (1855) map in favor of its present general location. The post-1870 delta prograded outward at the same time as longshore drift accreted sand westward, which built a sand spit in front of the delta. At the same time, longshore transport gradually eroded away and smoothed the delta and barrier spit associated with the 1855 delta; as well, longshore transport gradually eradicated the delta associated with Meadowbrook Creek in the mid 1800s. These barrier spits and the estuaries they created presumably resulted from the combination of longshore drift and the spits' outward deflection by freshwater transport from the river; when the river no longer flowed to the delta (the Dungeness River having abandoned the Meadowbrook Creek delta possibly a few hundred years before the historical period, and abandoning the early 1800s delta by 1870), the spits and estuaries disappeared or were greatly reduced. The post-1870 Dungeness River delta and its dynamic distributary and tidal channels have evolved through a combination of natural avulsion, human-intervention (diking and redirecting), fluvial deposition, longshore sediment transport, and coastal erosion. Net increase in area of the subaerial delta was most rapid in the first quarter of the 20^{th} century, after which the rate of increase gradually diminished in the middle two quarters of the century; in the last quarter of the century there was essentially no net area change.

The modern, forested riparian corridor of the lower Dungeness River corresponds roughly to the extent of the active (i.e., low flow and high flow) channel shown in 1914 County Assessor maps, which are the earliest reliable maps of the lower river. Since the early 1960s, levees have restricted the river's access to the entire corridor. Change to environments elsewhere on the coastal plain (to the southeast of Meadowbrook Creek) and in Graysmarsh and Washington Harbor consists mostly of draining freshwater wetlands, channelizing creeks, and the diking of saltmarsh.

Landscape-scale reconstructions of historical environments, such as the one presented in this report, have limitations and include cautions: they can't substitute for site-scale investigations, and certainty levels are inherently variable because they are based on incomplete information, and involve many assumptions and inferences, which users of such data are advised to examine. But a reconstruction such as this one does help establish an historical "reference condition" by describing earlier landforms and habitats and the processes that shaped them. It also provides insight into how different parts of the landscape have responded to different land uses and engineering measures, and point to the functions that are critical to restoring particular environments.

TABLE OF CONTENTS

List of Figures

List of Tables

INTRODUCTION

Objective

This study was undertaken for the Jamestown S'Klallam Tribe, Natural Resources Department to provide information to support efforts to restore the lower Dungeness River, the river delta, and the nearshore from the Dungeness Spit to Washington Harbor (Figure 1). The study uses historical maps, photographs, field notes, and text documents, along with high-resolution digital elevation models (DEMs) in a geographic information system (GIS) and geomorphic and ecological interpretation to describe the physical and ecological landscape and landscape processes at the mid 19th century, or around the time of earliest Euro-American settlement. It also describes changes to those environments from the mid 19th century to the beginning of the 21st century.

Study area

This report refers to the “greater Dungeness River area” to include the fan-shaped lowland that encompasses the Dungeness River downstream from the river’s exit from mountainous terrain of the Olympic Mountains, and the associated lowland drainage system (Figure 1). It extends westward to McDonald Creek, and eastward to Washington Harbor. This larger area is considered because doing so provides context for more detailed analyses of several areas of particular interest, including: the modern Dungeness River delta and associated nearshore; the lower Dungeness River to about RM 3; Gray’s Marsh (the local usage “Graysmarsh” is used in this report); and the Washington Harbor area (Figure 1).

This report refers to several valleys the Dungeness River formerly occupied (referred to in this report as “paleochannels”) at different times in the Holocene (roughly coinciding with the post-glacial period, which in the study area is the last 12,000 years). These include the “Bell Creek Dungeness River Paleochannel” (abbreviated “DRP” in this report), the “Gierin Creek DRP,” and the “Cassalery Creek

DRP" (Figure 2). Each is named informally for the creek now occupying it. The "Dungeness River valley" in this report refers to the modern valley of the Dungeness River, delineated by the occurrence of recent alluvium and an elevation lower than the terraces of older alluvium corresponding to the paleochannels described above. These paleochannels and the physical history of the study area are described in detail in the following section of the report.

Figure 1. Extent of the study area, referred to in this report as the "greater Dungeness River area." Sections of the report also concentrate on four areas: (A) the Dungeness River delta and associated nearshore; (B) the lower Dungeness River; (C) Graysmarsh, and (D) the Washington Harbor area.

HOLOCENE HISTORY UP TO THE TIME OF SETTLEMENT (MID 19TH CENTURY)

Paleo-Dungeness River channels and surfaces

The Greater Dungeness River area was ice-free 12,100 ± 310 ybp [years before the present] (Petersen et al. 1983). Following, and possibly coincident with deglaciation, the paleo-Dungeness River incised into glacial and glaciomarine deposits (generalized in Figure 2 as Qgd, Quaternary glacial drift), creating several distributary channels. Three paleo-channels of the Dungeness River (the Bell Creek, Gierin Creek, and Cassalery Creek DRPs) are mapped as "older alluvium" (Qoa in Figure 2); the Dungeness River valley is mapped as "recent alluvium," (Qa).

Stratigraphic evidence indicates that the Dungeness River abandoned the Bell Creek DRP in the first half of the Holocene. Surficial sediments about 1.5 km east of Sequim consist of fluvial gravels overlain by sandy/silt muck, which is overlain by about 10 cm of peat radiocarbon dated to 6,780 ± 60 ybp (Hartmann, 1997, referenced in Gough, 1999). A layer of Mazama ash lies on top of the peat layer, and the ash in turn is overlain by 70 cm of peat dated to 6,300 + 60 ybp. The Mazama ash and radiocarbon dates indicate that the paleo-Dungeness River incised and abandoned the Bell Creek Paleochannel by 6,780 ybp, at the latest (Gough, 1999).

No other published data for dating the Dungeness River's abandonment of the other two paleochannels was found. A high-resolution DEM made from lidar (Terrapoint, 2001) shows a number of escarpments on the Gierin Creek and Cassalery Creek DRPs (Figure 2), which indicates incision by the Dungeness River to elevations lower than the Bell Creek DRP surface. This evidence of incision is consistent with the hypothesis that the paleo-Dungeness River consecutively incised and abandoned the Bell Creek DRP, the Gierin Creek DRP and later the Cassalery Creek DRP, prior to incising again to create the modern Dungeness River valley. The three DRPs have successively gentler land gradients: 0.015, 0.012, 0.009, for the Bell, Gierin and Casselary creeks DRPs, respectively, and 0.008 for the Dungeness River valley (Gough, 1999). This trend in decreasing slope of the four surfaces indirectly supports the interpretation of successive incision, because the declining gradients could represent each surface having been graded to a successively higher sea level, as Holocene sea levels rose (see below). It directly supports the interpretation that these four surfaces are distinct. An escarpment on the Bell Creek DRP near Port Washington also suggests the possibility of earlier, higher surfaces than the Bell Creek DRP.

The coastal plain and alluvial fans

A coastal plain (mapped as Qcp in Figure 2) extends from about Cline Spit to near the town of Jamestown. It also extends as much as two nautical miles into the Strait of Juan de Fuca as a shallow wave-cut platform (Figure 3); this presumably reflects an early Holocene shoreline when sea levels were lower than at present (see below for more discussion).

A large alluvial fan associated with the Cassalery Creek DRP is built onto the coastal plain (Figure 4), mapped in Figure 2 as "older Dungeness River alluvial fan" (Qodrf). The large volume of this fan, and the large amount of sedimentation it implies, is consistent with the paleo-Dungeness River having occupied the Cassalery Creek DRP for a long period. A second large fan has built onto the coastal plain to the west of this older fan, and nearly coalesced with it. Associated with the modern Dungeness River (Figure 4), this second fan is building actively. The modern Dungeness River fan is smaller than the fan associated with the Cassalery Creek Paleochannel. It is notably asymmetric toward the southeast, and less developed on its north-northwest area, which corresponds to the modern Dungeness River delta (Figure 4).

In contrast to the Dungeness River valley and the Cassalery Creek DRP, the Gierin Creek and Bell Creek DRPs lack alluvial fans; the Gierin Creek DRP grades to Graysmarsh (which was historically saltmarsh), and the Bell Creek DRP grades to sea level in the Port Washington lagoon. This presumably reflects in part the differing nearshore bathymetry of the three areas. Additional possible, speculative reasons for this include its having resulted from sea level having been lower when the Dungeness River occupied the Gierin and Bell DRPs compared to when it occupied the Cassalery Creek DRP and the Dungeness River valley. Sea level in the Victoria, BC area was as much as 50 m lower than now 9,000-11,000 ybp (Linden and Schurer, 1988), and 5,470-9,250 ybp it was at least 11 m lower than now (Clague 1982). This early-Holocene sea level may correspond to the wave-cut submarine bench evident in Figure 3, which is roughly 12 m below sea level. Sea level by approximately 5,000 ybp had risen to within 2-3 m of the modern level (Beale, 1990, Clague et al., 1982). Another possible reason (or contributing reason) for the absence of large alluvial fans in the Gierin and Bell Creek DRPs could be that the Dungeness River occupied the Gierin and Bell Creek DRPs for less time than it occupied the Cassalery Creek DRP.

Latest Holocene (prior to the earliest map record) history of the Dungeness River's delta

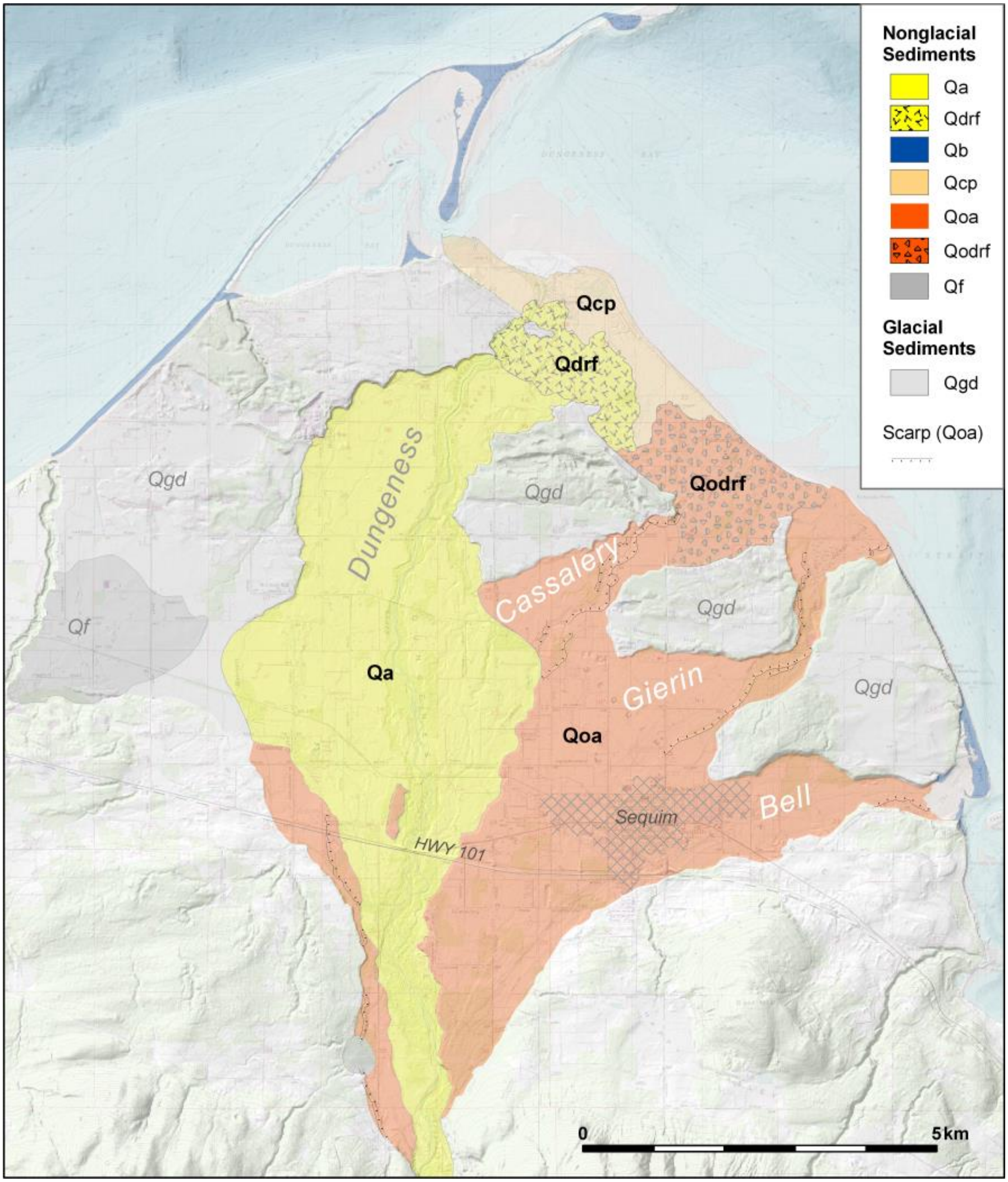
Within the area of the Dungeness River fan, the Dungeness River has had a number of locations and built a number of different deltas. Several lines of evidence argue that the Dungeness River has been building the delta in its current general location in the recent past, possibly for only a few hundred years. If so, it provides important context for understanding the modern delta and modern sedimentation at the delta and in Dungeness Bay.

The first argument for this interpretation is simply the prominence in the earliest (mid 19th century) mapping of a delta associated with an earlier location of the Dungeness River, in which the Meadowbrook Creek channel now flows (Figure 2; see also Figure 6). This Dungeness River paleochannel and associated delta are referred to here as the "Meadowbrook Creek Dungeness River Paleochannel (or "Meadowbrook Creek DRP"). In the earliest mapping (1855, USC&GS map T-0539; see Figure 6), the Meadowbrook Creek delta protruded conspicuously into Dungeness Bay. In light of interpretation later in this report on the interactions of longshore sediment transport with fluvial processes in the evolution of nearshore landforms, that the delta protrudes into Dungeness Bay suggests that fluvial sedimentation dominated over longshore drift in the few decades prior to the earliest mapping. This argument is bolstered by the morphological distinctness of the Meadowbrook Creek DRP, a relict channel comparable in size to the modern Dungeness River (Figure 5) that diverges from the Dungeness River at RM 2.5. This distinct morphology implies that a great deal of time has not passed since the Dungeness River abandoned the channel (i.e., with increasing time since abandonment, the paleochannel and its banks would become more rounded and indistinct).

A second argument for the Dungeness River delta having been active for a relatively short period of time is the likelihood that the Dungeness River was until recently topographically isolated from its current delta. The river currently flows through a narrow notch between the glacial upland to the west and a several-hectare detached piece of that upland (traversed northwest-southeast by Schoolhouse Road; see Figure 5). A recent study suggested the Dungeness River has been pinned between the detached glacial upland and the main glacial terrace to the west for many thousands of years (Bountry et al., 2002). This could be less likely than a competing explanation, for two reasons. First, the notch is only 100 m wide; if the Dungeness River had been located in the notch for more than a few centuries, it is likely to have eroded a wider valley; elsewhere, upstream, the Dungeness River valley has eroded a valley that is between 2 and 5 km wide into the glacial sediments. This first argument could be countered by the observation that the glacial sediments are cohesive and erosion-resistant, which could have resulted in very low rates of lateral erosion. However, the topographic shape of the Dungeness River fan is the basis for a second, less equivocal argument (Figure 4). The fan morphology shows that most sedimentation from the Dungeness River valley has been directed to the east-southeast. A significant lobe of deposition is also present in the area of the Meadowbrook Creek DRP (which also bolsters the interpretation of the recent activity of this paleochannel and delta, made earlier; note in Figure 4 that the town of Dungeness was located on this fan lobe, which is a few meters higher than the surrounding coastal plain). This latter deposition originated because the eastern margin of the detached glacial upland likely deflected the river eastward. There is very little deposition associated with the current location of the Dungeness River (Figure 4). This topographic evidence, bolstered by the (arguable) point that the notch is only 100 m wide, suggests that the river until recently was deflected eastward by the glacial upland remnant, in the process of carving away at the upland, and only recently broke through to create the notch. This interpretation is also supported by the topographic evidence for a paleochannel at the base of the glacial upland remnant that could be an expression of a (relatively recent) Dungeness River that was deflected by the upland remnant. If it is correct that the Dungeness River has passed through the Schoolhouse notch only recently, the area of the modern Dungeness River delta would have been isolated from the river until recently, when the river created the notch.

The third argument for the recent dominance of the Meadowbrook Creek DRP delta is that the historical morphology of the Meadowbrook Creek estuary is suggestive of the Dungeness River having only recently abandoned it (in the decades prior to the first, 1855 mapping). In the 1855 map the Meadowbrook Creek delta had the morphology of an active estuary created by a large flow of water (see later, Figure 6). The estuary's morphology was almost identical to that of the modern Dungeness River estuary during much of its history. In the years following 1855, longshore drift closed the estuary, and smoothed the coastline, erasing the formerly protruding delta (see later, Figure 23). This same sequence of events happened to the 1855 Dungeness River estuary following the river's abandonment by 1870 for the modern estuary (see later, Figure 15). The details of this last argument, and the history of these three estuaries—the likely pre-1855 estuary (the Meadowbrook Creek DRP), the 1855 estuary, and the 1870-onward (modern) estuary are discussed later in the report.

Figure 2 (following page). Generalized Quaternary geology of the study area. Qa = recent alluvium associated with the modern Dungeness River valley; Qdrf = alluvial fan associated with recent alluvium from the modern Dungeness River valley; Qb = beach; Qcp = coastal plain; Qoa = older Holocene alluvium; Qodrf = alluvial fan made of older alluvium in the Cassalery Creek DRP; Qaf = alluvial fan, early Holocene or late Pleistocene; Qgd = Pleistocene glacial drift, generalized; "Scarp Qoa" = scarps visible on lidar within the Qoa map unit. Large font "Bell DRP," Gierin DRP," etc. refer to Holocene paleochannels of the Dungeness River. Coastline is from 1855-1870 US Coast & Geodetic Survey Topographic Sheets (see Table 1). Geologic mapping is from Schasse and Wegman (2000), Schasse and Logan (1998), and from topographic interpretation made for this study.


Nonglacial Sediments
Qa
Qdrf
Qb
Qcp
Qoa
Qodrf
Qf
Glacial Sediments
Qgd
Scarp (Qoa)
Qcp
Qdrf
Qgd
Dungeness
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Cassalery
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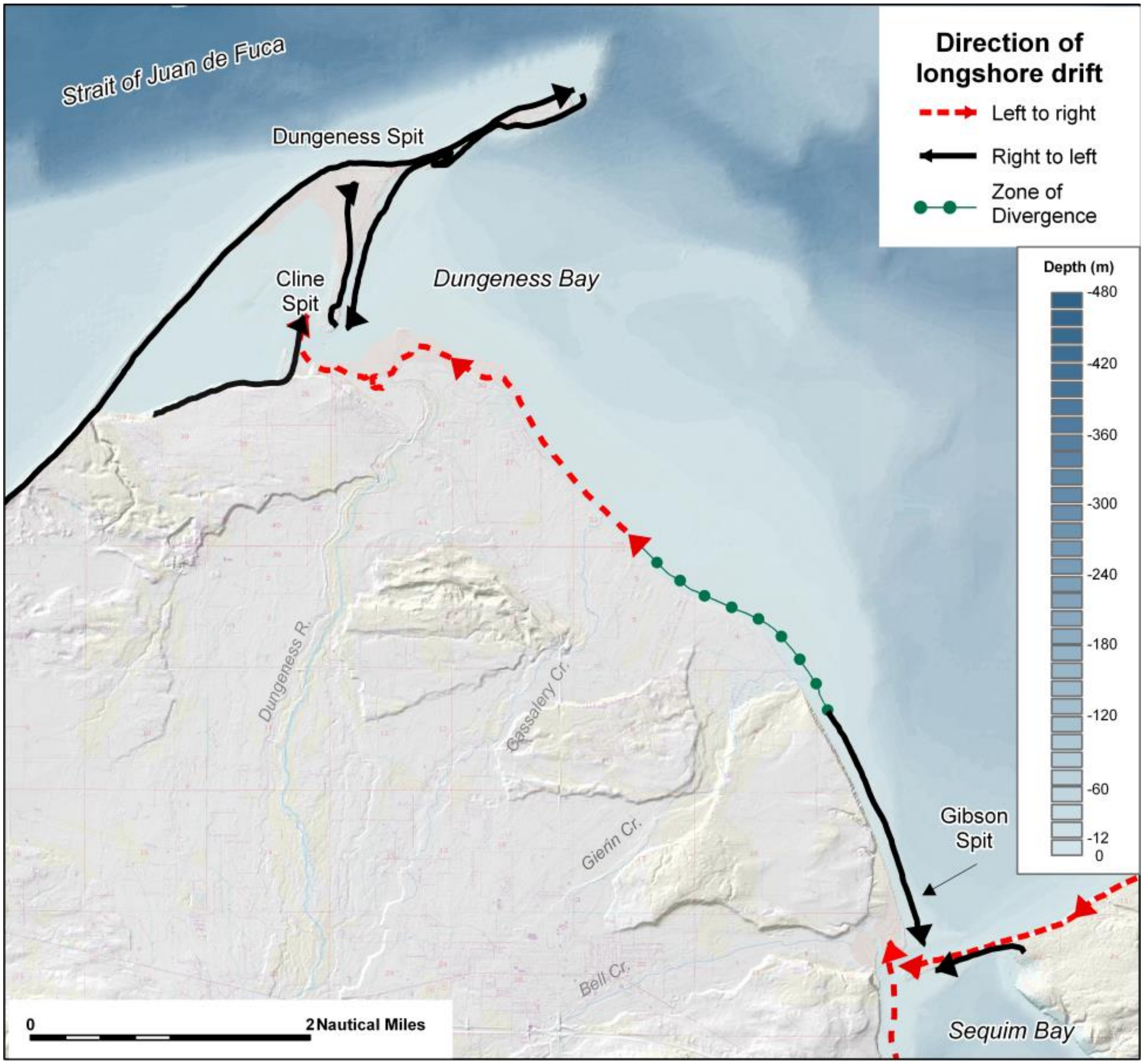

Figure 3. Drift cells in the study area, from Washington State Department of Ecology (2002). Direction of transport is for an observer facing the shore. Bathymetry is from Finlayson (2005).

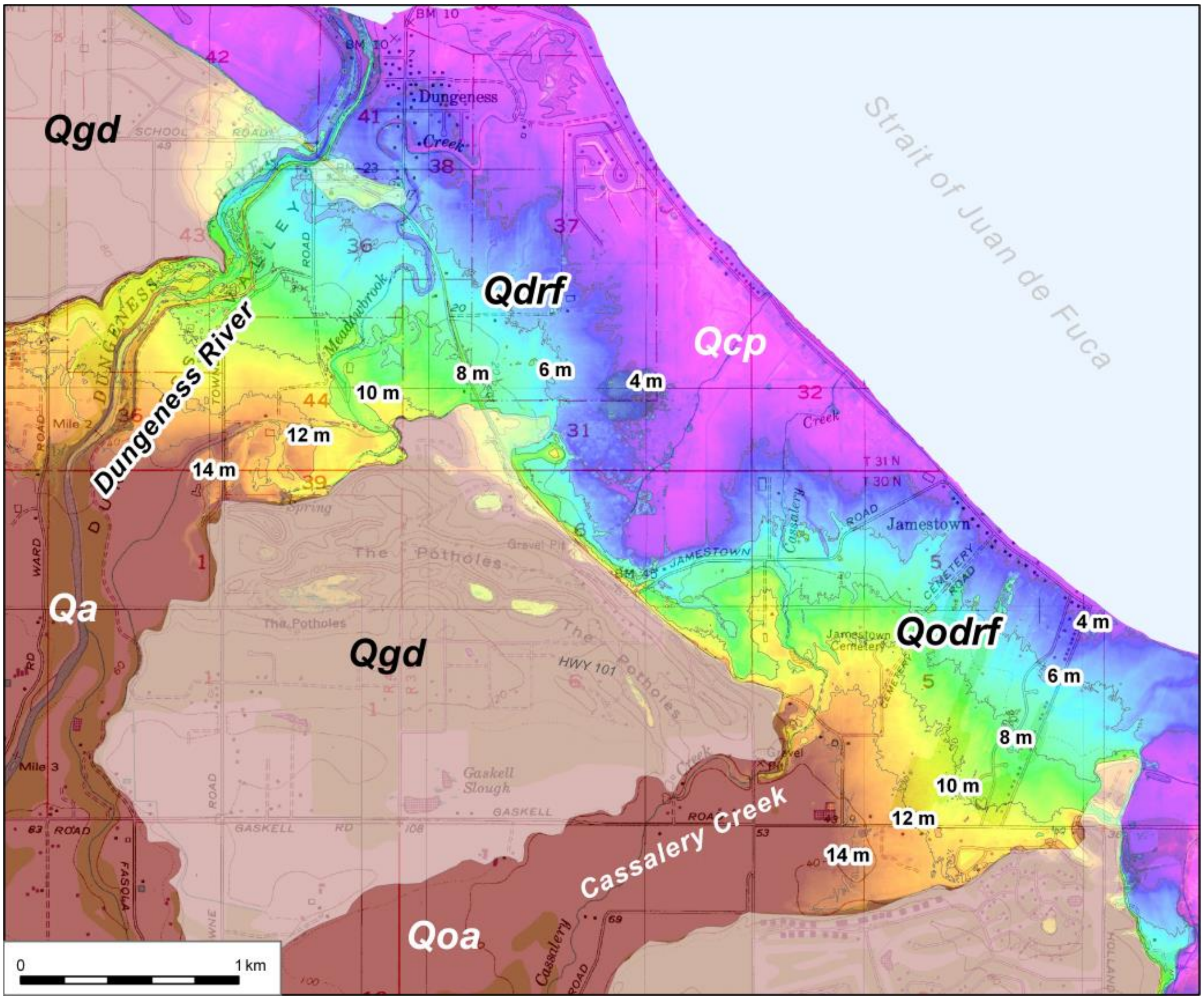

Figure 4. Topography of the coastal plain, from lidar (Terrapoint, 2001). Two-meter contour intervals are labeled. Geologic units are as in Figure 2. USGS topographic mapping is overprinted on topographic imagery for location reference; the settlement of Jamestown is on the lower margin of the alluvial fan from the Cassalery Creek DRP, and the town of Dungeness is on the modern Dungeness River alluvial fan. Also note the isolated remnant of glacial upland SW of the town of Dungeness, which is shown in more detail in Figure 5.

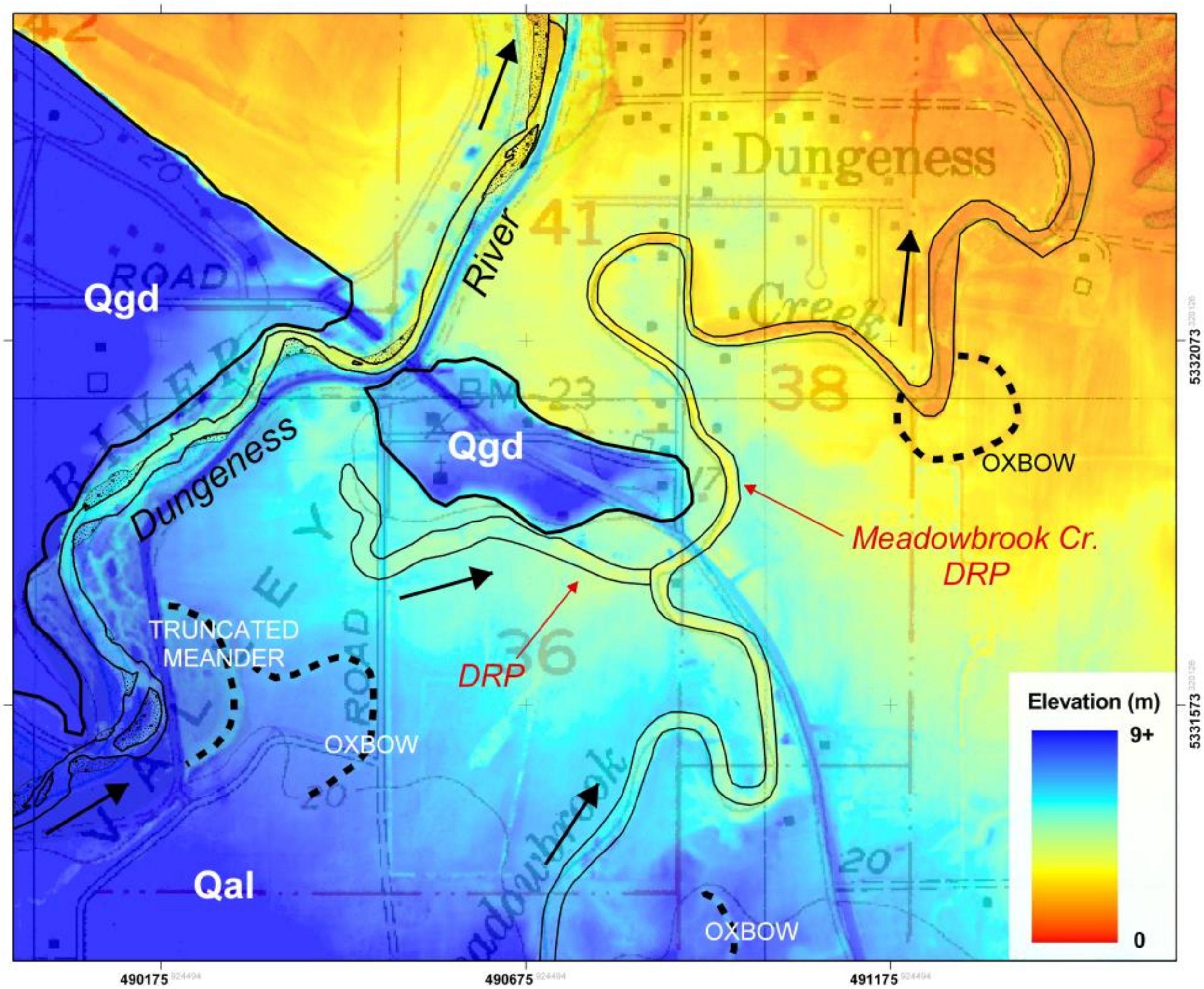

Figure 5. Topography of the lower Dungeness River valley and upper Dungeness River Fan. Hatched area depicts higher elevations associated with the Meadowbrook Creek DRP and a lobe of the Dungeness River fan (see Figure 4). The topographic traces of a possible DRP at the south base of isolated remnant of glacial sediment and the "Meadowbrook Creek DRP" (see text) are outlined in black. "Oxbow" refers to subtle topographic expressions of likely former oxbow channels. "Truncated meander" refers to a bend of the Dungeness River isolated from the river by dikes, which are visible in the figure as high-elevation linear features. Tic marks are every 500 m referenced to UTM North.

METHODS AND SOURCES USED TO RECONSTRUCT HISTORICAL CONDITIONS

Mapping sources. Topographic sheets ("T-sheets"), surveyed in the study area starting in 1855 by the US Coast & Geodetic Survey (USC&GS), are the primary map source for the historical nearshore (Table 1). The T-sheets were supplemented by hydrographic sheets ("H-sheets"), also made by the USC&GS in the same time period, primarily as a source for the low water line. Inland, plat maps and field notes of the General Land Office (GLO) survey are the primary source for land cover and hydrologic features, field-surveyed in 1858 (and published in 1859) in the greater Dungeness area (Table 1). The GLO documents were supplemented by: 1942 and 1963 aerial photographs (both at 1:20,000 scale; see Table 1), particularly for showing traces of former channels and remaining fragments of historical wetlands; 1914 Clallam County tax assessor maps; soils and land use mapping from 1910; high-resolution DEMs from lidar; and other map and photo sources (Table 1). We georeferenced (maps) or orthorectified (aerial photos) images and brought them into a GIS. For more information on T- and H-sheets see Shalowitz (1964) and on GLO plat maps and field notes, see White (1991) and Whitney (2001); for background information on how they are used in this analysis, see Collins et al. (2003).

Mid-19th century channels. The T-sheets are generally the most reliable source for mapping channels in the nearshore area. Inland, the GLO surveyors generally "meandered" (field surveyed, using bearings and distances along the channel edge) navigable channels (see White, 1991 for detail). The Dungeness River was not meandered, and so the river as shown on the plat maps is only accurate where it was crossed by section lines, and sketched in between. In the absence of accurate 19th century mapping, the 1914 tax assessor records are the first detailed mapping of the Dungeness River; the historical conditions mapping (Figures 7 and 8) uses it as a best-available representation of conditions several decades earlier.

The GLO's mapping of all other, smaller channels is also generally reliable only near section lines, where surveyors noted and measured them. Early topographic maps published by the U. S. Geological Survey are imprecise and show only the larger channels because of the mapping's small scale. Because both of these early map sources either incompletely or inaccurately depict small channels, to map smaller channels in between their known locations at section lines, substantial use was made of the 1942 and 1963 aerial photos, which show traces of relict stream channels. The GLO field notes are a unique source of small channel widths, field measured and recorded to the nearest half link (1/2 link = 10 cm). These field-measured channel widths are the source of small channel widths coded into the GIS mapping.

Mid-19th century land cover. In the nearshore, T-sheets were the primary source for land cover, supplemented by GLO field notes. Elsewhere, the GLO plat maps are the primary source for mapping wetlands, forest openings (termed "prairies" in the GLO notes), and forests. Similar to their treatment of small channels, the GLO survey generally noted and mapped wetlands only where encountered along a section line. These map sources are supplemented to identify wetlands in a few cases by 1942 and 1963 aerial photographs, the extent of organic soils shown on recent and older soils maps, and wetlands mapped on recent topographic maps (Table 1).

Bearing tree records from the GLO survey notes were used to characterize historical forest conditions (see Collins et al., 2003, for background). With a few exceptions, the mapping in this project did not distinguish forest communities except by geomorphic location (i.e., on floodplains, terraces, or fans; see Figure 10). Exceptions are two forest subtypes mapped on the coastal plain and alluvial fans, an alder forest and areas of the coastal plain characterized by brushy deciduous forest or by alder forest. Bearing trees characterize the diameter, species frequency, and basal area of forest trees (see Figures 9-11), for the purpose of characterizing the nature of wood that would have recruited to the Dungeness River; see Collins et al. (2003) for additional background.

The plat maps and field notes include open patches in the forest cover, which federal surveyors generally called "prairies." Many or most of the forest openings were probably created and maintained with fire by indigenous populations as demonstrated in numerous Pacific Northwest environments (e.g., see Boyd 1999) including the extensive prairies of southwest Washington (Leopold and Boyd, 1999).

Because patches are often small relative to the square-mile grid used in the public land survey, the GLO survey could have missed many of the smaller prairies and so the mapping in this report may not show all of the smaller prairies and is biased toward the larger ones.

Map certainty. Reconstructing landscapes that no longer exist or that have experienced substantial change is inherently uncertain. To constrain and minimize uncertainty, in this project, multiple cross-referencing sources have been used wherever possible. Each source provides different types of information, at different scales and spatial densities, at different times, and with different reliabilities. In the estuary area, the GLO plat maps provided very little useful information, but the GLO field notes, although restricted to along survey lines, provided critical information on the land character and land cover (Figure 6). It was also necessary to make judgment calls in evaluating the relative reliability of overlapping sources. For example, the USC&GS surveyed the delta in 1855 (T-0539) and again in 1870 (T-1168); the 1855 sheet was made when there had been much less settlement and land use change compared to the 1870 sheet, but on the other hand the earlier sheet did not extend as far inland, and information on its inland margin was less reliable (when cross-referenced to other sources). For each map feature (excepting generalized forest map units), Appendix 1 provides the sources and logic with which the sources were used to derive mapping in Figures 7 and 8.

Mapping historical change. Various map (Table 1) and aerial photo (Table 3) sources were used to characterize landscape change in the century and a half following the mid-19th century period. Different sources have unique strengths and weaknesses and differing geographic coverages (Table 1).

Table 1. Maps used in study, 1859-2002. Source: 1 = Clallam County; 2 = UW libraries; 3 = Bureau of Land Management; 4 = National Archives.

YEAR and SOURCE	TYPE & SCALE	TITLE	AREA
1859[3] (from 1858 field surveys)	General Land Office plat maps 1:31,680	T31N R4W (1859)	RM 0-2 & Dungeness Spit
		T31N R3W (1859)	Nearshore Dungeness River to Jamestown
		T30N R3W (1859)	Nearshore Jamestown to Washington Harbor
		T30N R4E (1859)	RM 2-9
		T29N R4W (1893)	RM 9-13
1855[4]	US Coast & Geodetic Survey T-sheet 1:10,000 or 1:20,000	USC&GS T-539. 1:10,000. “Map of New Dungeness, Strait of Juan de Fuca, Washington Ter.” (J. Lawson).	Dungeness Spit to Jamestown
1870[4]		USC&GS T-1168. 1:10,000. “Part of New Dungeness, Strait of Juan de Fuca, Wash. Ter.” (J. Lawson)	Dungeness River to Jamestown
1870[4]		USC&GS T-1169. 1:10,000. “Part of New Dungeness, Strait of Juan de Fuca, Wash. Ter.” (J. Lawson)	Jamestown to Washington Harbor
1907-08[4]		USC&GS T-2859. 1:10,000. “Morse Creek to Dungeness, South Shore Strait of Juan de Fuca, Washington,” (C. G. Quillian et al.)	Morse Creek to Dungeness River
1926[4]		USC&GS T-4193. 1:20,000. “New Dungeness to east side of Port Angeles, Strait of Juan de Fuca-South Shore, Washington.” (C.I. Aslakson).	Dungeness River to western boundary study area
1926[4]		USC&GS T-4194. 1:10,000. “Mouth of Washington Harbor to New Dungeness, Strait of Juan de Fuca-South Shore, Washington.” (C.I. Aslakson).	Dungeness River to Washington Harbor

Table 1 (continued). Maps used in study, 1859-2002. Source: 1 = Clallam County; 2 = UW libraries; 3 = Bureau of Land Management; 4 = National Archives.

YEAR and SOURCE	TYPE & SCALE	TITLE	AREA
1855[4]		USC&GS H-500. 1:10,000. "Hydrography of New Dungeness, St. of Juan de Fuca (W.T.)." (J. Alden).	Dungeness Spit to Jamestown
1881[4]	US Coast & Geodetic Survey H-sheet 1:10,000 or 1:20,000	USC&GS H-1516A. 1:20,000. "Port Discovery, Washington Harbor and Approaches, Washington Territory." (Lt. P. Garst).	Jamestown to Washington Harbor
1882[4]		USC&GS H-1534. 1:10,000. "Straits of Juan de Fuca and entrance to Admiralty Inlet, Washington Territory." (T. D. Bolles).	Tip of Dungeness Spit to Jamestown
1926[4]		USC&GS H-4573. 1:20,000. "New Dungeness Bay & Washington Harbor, Strait of Juan de Fuca, Washington." (O. S. Reading).	Dungeness Spit to Graysmarsh
1940[4]		USC&GS H-6650. 1:10,000. "Green Point to Dungeness, Strait of Juan de Fuca, Washington." (E. B. Latham and C. J. Wagner).	Dungeness Spit to Green Point
1940-1941[4]		USC&GS H-6651. 1:20,000. "Dungeness Bay, Strait of Juan de Fuca, Washington." (P.C. Doran).	Dungeness Bay

Table 1 (continued). Maps used in study, 1859-2002. Source: 1 = Clallam County; 2 = UW libraries; 3 = Bureau of Land Management; 4 = National Archives.

YEAR and SOURCE	TYPE & SCALE	TITLE	AREA
No date (reconnaissance 1909, field work and compilation 1914)[2]	15' U.S. Army Corps of Engineers topographic 1:62,500	Dungeness	Greater Dungeness area
1910[2]	US Bureau of Soils Soil survey and land use classification maps	USDA Bureau of Soils. 1912. "Reconnaissance soil survey of the western part of Puget Sound." (A.W. Mangum and party).	Greater Dungeness area
1914[1]	Tax assessor records; original scale unknown, digital images of individual land sections	Clallam County Assessor Records	Greater Dungeness area
1917[2]	Land ownership maps	Atlas of Clallam County, Kroll Map Company, Seattle, Washington.	Greater Dungeness area
1926[2]	USGS planimetric	Dungeness River Washington (E.E. Jones)	RM 0-10
1937[2]	15' U.S. Army Corps of Engineers topographic 1:62,500	Dungeness	Greater Dungeness area
1956, photorevised 1979 (1980 bathymetry)[2]	USGS topographic 1:24,000	Dungeness, Wash.	RM 0-2 Dungeness Spit to Jamestown

Table 2. Aerial photographs used in study, 1942-2003. Source: 1 = Jamestown S'Klallam Tribe; 2 = Clallam County Conservation District; 3 = UW libraries; 4 = US Bureau of Reclamation.

YEAR	SCALE	TYPE	COVERAGE (RIVER)	COVERAGE (NEARSHORE)	SOURCE
1942-43	1:20,000 (1942) 1:30,000 (1943)	B/W	1942: RM 0-7 1943: RM 7-10	Dungeness R. to Jamestown	4
1963	1:20,000	B/W	RM 0-7	McDonald Cr. to Washington Harbor	2
1965	1:12,000	B/W	RM 3.5-10	(no nearshore coverage)	4
1972	1:24,000	B/W	RM 0-2	Dungeness Spit to Dungeness R. delta	3
1975	1:24,000	COLOR	RM 0-5	Dungeness Spit to Washington Harbor	2
1990	1 m resolution	B/W USGS DOQQ	RM 0-2	Dungeness R. to Jamestown	3
1994	1 m resolution	B/W USGS DOQQ	RM 2-13	Dungeness R. to Jamestown	3
1994	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta	1
1995	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta	1
1996	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta	1
1997	1:6,000	COLOR	RM 0-3	Dungeness R. delta	1
1998	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta	1
1999	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta to Dungeness Spit	1
2000	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta to Cline Spit	1
2001	1:6,000	COLOR	RM 0-2	Dungeness Spit to Graysmarsh	1
2002	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta	1
2003	1:6,000	COLOR	RM 0-2.5	Dungeness R. delta	1

Figure 6 (following page). The Dungeness River delta area, from three early sources: T-0539 (1855), GLO plat maps and relevant excerpts from surveyor's line notes[1] (1859, field survey 1858), and T-1168 (1870). Color was added to T-sheets to enhance visual interpretation.

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1 Full text of line notes excerpted in Figure 6. B racketed information and "chains" has been added for clarity:

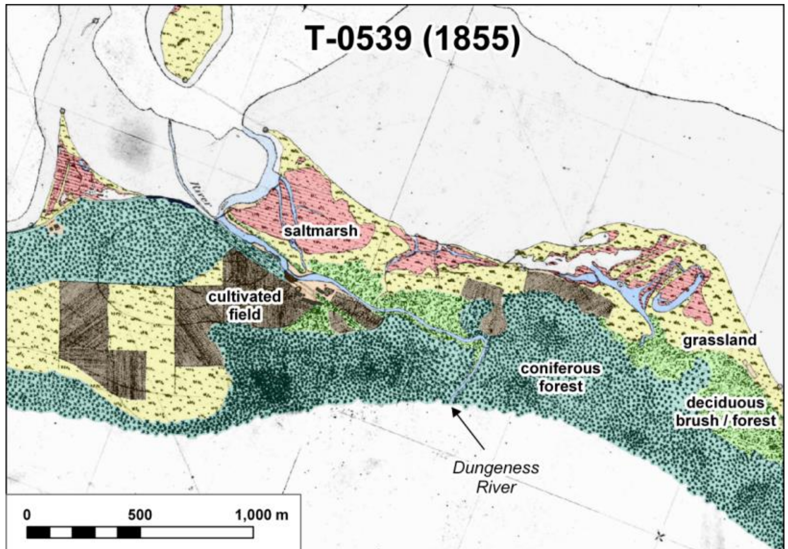
"North on West boundary of Section 30, Variation 21 E
14.00 chains—Leave brush & enter low marsh, E. & W
23.70 chains—Intersect shore of Straits & set meander post between Sections 25 & 30, no trees convenient. Drove charred stake & raised mound with trench & pits, Set flag over in line to Dungeness Spit….[May 6th 1858]."

"East bet. secs. 30 & 31, Var. 21 E.
18.50 chains—Creek 75 lks. Runs N. E.
21.32 chains—Creek 75 lks. Runs S. E.
25.50 chains—Same Creek runs N. E. & enter field
27.10 chains—Barrows House bears N 20 E
31.47 chains—Leave field N. E. & S. E. Barrows house bears N 40 W.
34.00 chains—Leave prairie & enter brush N 70 E & S 70 W
39.25 chains—Set ¼ section post from which, A Willow 4 in. dia. bears S. 53 W 8 liks. Dist., A Willow 3 in. dia. bears N. 60 E. 10 lks dist.
46.00 chains—Enter prairie N 70 W & S. 70 E.
47.20 chains—Cross fence N. E. & S. W.
51.25 chains—Leave field N. & S.
51.70 chains—Set meander post on beach between Section 30 & 31 no trees convenient. Drove charred stake & raised mound Land level soil 1st rate Undergrowth briers gooseberry willows &c. May 12th 1858."

"North on West boundary of Section 31 Var. 21 30 East.
[first part of line not shown on Figure 2 deleted]
40.00 chains—Set ¼ Section post from which, An Elder 8 in. dia. bears S 71 E 58 links dist., A Maple 60 in. dia. bears N 80 W 8 liks. Dist.
46.50 chains—Creek 30 links runs N. E.; 52.75 chains—Same Creek runs West.
56.30 chains—Same Creek runs N. E.; 66.00 chains—Enter S. E. Corner of clearing E. & W.
67.50 chains—house bears West about 100 links
69.35 chains—Same Creek runs N. 30 W. & leave Clearing
78.75 chains—Same creek runs East; 80.00 chains—Set post Corner to sections 25, 30, 31 & 36, from which, A maple 18 in. dia. bears N. 17 E liks dist., A Maple16 in. dia. bears N 88 W 93 links dist., A Maple21 in. dia. bears S. 39 W. 92 links dist.;Land level, Timber Maple, alder, fir &c, Undergrowth gooseberry, Crabapple briers nettles &c. &c, Soil 1st rate. [May 6th, 1858]."

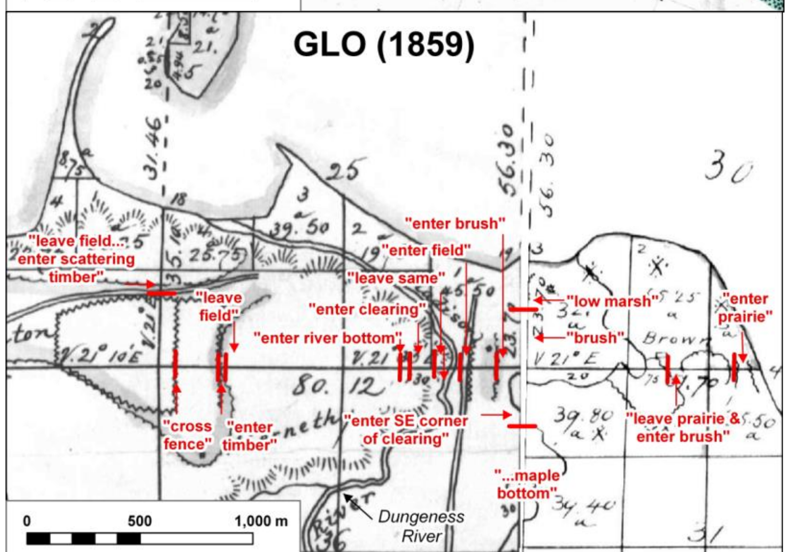
"East on random line bet. secs. 25 & 36, Var. 21 East
3.60 chains—Cross fence N. & S.
13.00 chains—Enter timber N. & S.
13.60 chains—Leave field N & S.
40.00 chains—Set temporary ¼ sec. Post
51.50 chains—Descend N. E. & S. W.
52.75 chains—Enter river bottom N. E. & S. W.
54.75 chains—Enter clearing N. E. & S. W.
60.75 chains—Leave same
64.20 chains—Dungeness River 130 lks wide course N. 30 E.
66.40 chains—Cross road & enter field N. 30 E. & S. 30 W. Madisons House bears N. 42 W.
75.00 chains—Enter brush Madison's house bears N. 25 W.
80.12 chains—Intersect E. boundary 77 lks. South of post
"West on true line bet. secs. 25 & 36, Var. 21 33 East
40.06 chains—Set ¼ sec. Post from which a fir 12 in. dia. bears S. 52 E. 32 liks. dist., a fir 8 in. dia. bears N. 39 W. 38 lks dist.
80.12 chains—To section corner. East 27 chs. in river bottom soil 1st rate balance rolling. Soil 2nd rate. Timber chiefly fir. [June 2nd 1858]."

A



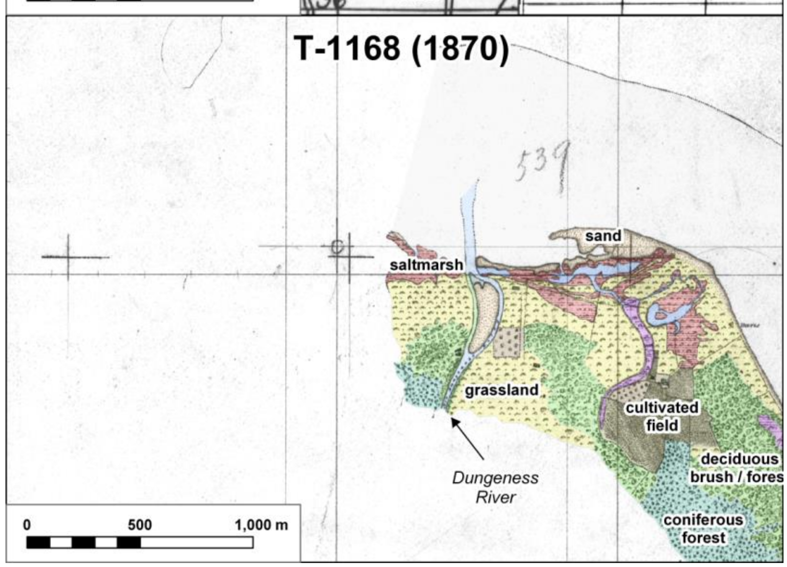
T-0539 (1855)
saltmarsh
cultivated field
grassland
coniferous forest
deciduous brush / forest
Dungeness River
0
500
1,000 m

B



GLO (1859)
"leave field... enter scattering timber"
"leave field"
"cross fence"
"enter timber"
"enter brush"
"enter field"
"leave same"
"enter clearing"
"enter river bottom"
"enter SE corner of clearing"
"...maple bottom"
"low marsh"
"brush"
"enter prairie"
"leave prairie & enter brush"
Dungeness River
0
500
1,000 m

C



T-1168 (1870)
sand
saltmarsh
grassland
cultivated field
deciduous brush / fores
coniferous forest
Dungeness River
0
500
1,000 m

LANDSCAPE AT THE TIME OF FIRST SETTLEMENT

Figures 7 and 8 show the historical landscape reconstructed for the greater Dungeness River area. The historical view draws primarily on source materials from the third quarter of the 20th century (1855-1870), and seeks to describe landscape conditions at the time of first settlement in 1851.

The low water line (the outer limit of "intertidal" in Figures 7 and 8) is from the two earliest H-sheets, H-500 (1855) from the Dungeness Spit eastward to about Cooper Creek, and from H-1516a (1881) to Washington Harbor. Note that the low water line between Graveyard Spit and the Dungeness Spit is a straight line. The straight line is not intended to represent the low water line; H-500 didn't map the low water line in the shallow water to the north, leaving an information hole, the straight line only connects the two ends of the surveyed low water line.

The two H-sheets used different datums. Beginning in 1854, the USC&GS used as datum the mean of the lowest low water of each 24 hours, which is considered to be the same as mean lower low water (Shalowitz, 1964). Some time during the late 1870s, the plane was changed to the mean of selected lowest low waters. In Puget Sound, this plane was 3.2 feet below the plane of mean lower low water. [In 1897, the datum was changed to the harmonic or Indian tide plane. In 1902, the plane of reference the plane of reference was changed to 2 feet below the plane of mean lower low water. The plane of mean lower low water was finally readopted in 1921, and remains in use; see Shalowitz (1964).] We have not attempted to translate the low water line on the H-sheets to the modern datum.

The delta and nearshore: Dungeness River to Jamestown

The Dungeness River delta in the earliest (1855) map was west of its modern location (Figure 8). The earliest map shows a large saltmarsh, which is separated on its northeast side from Dungeness Bay by a strip symbolized as "grassland." It is reasonable to assume that this was grassy sand, because of the feature's morphology, and because the same surveyor, 15 years later, in a more detailed T-sheet of the same area, symbolized as “sand” the same feature he previously symbolized as “grassland” on the Meadowbrook Creek delta (see Figures 6A and 6B). The General Land Office survey notes add no information on these features, the survey not having crossed them (see Figure 6B).

The Meadowbrook Creek delta—presumed to be associated with a late-Holocene location of the Dungeness River—had a morphology similar to that described above. The Meadowbrook Creek delta area appears older and more complex than the Dungeness River delta, comprising an estuary, lagoons, and a spatially complex pattern of saltmarsh. Note that the patch of saltmarsh immediately south of the Meadowbrook estuary shown in Figure 8 was mapped 15 years previously as a cultivated field (Figure 6A). However, the 1859 GLO survey transected the area and in the line notes call it a “low marsh” (Figure 6B), and the 1870 T-1168 symbolizes it as saltmarsh (Figure 6C). Possibly the 1855 survey was in error, because the 1855 and 1870 surveys were by the same person, or possibly an early attempt to cultivate the low-lying coastal marsh was abandoned after only a few years and became (or reverted to) marsh. That the GLO survey notes it as “low marsh” while the T-sheet symbolizes it as saltmarsh may mean it was difficult for surveyors to determine if it was salt or fresh marsh.

Figures 7 and 8 map as deciduous forest/brush a large area on the lower elevations of the Dungeness River valley fan [referred to as a “low flat” in descriptive information filed with T-2859 (Dibrell, 1908)]. This is based on the use of deciduous forest symbology on the T-sheets, and on the descriptor “brush” in the GLO line notes. Additionally, bearing trees from the “brush” area are deciduous—willow, maple, alder, and crabapple—except for one fir, although the sample size is very small (n=9, survey points=3). Appendix 1 has more detail.

A large complex of wetlands extends southeast along the coast from Meadowbrook Creek toward Gierin Creek (Figure 8). The wetland on the coastal plain between Cassalery Creek and Meadowbrook Creek (see DNG_W3103001 in Appendix 1) is shown as freshwater in Figures 7 and 8. The two T-sheets (T-0539 in 1855 and T-1168 in 1870) map the area as a combination of grassland, wetland and deciduous forest. The wetland symbol in both (as indicated above, the same surveyor drew both maps) is not the standard symbol for freshwater marsh (dashed lines) or for saltmarsh (solid lines), instead consisting of patches of solid lines; this could be intended to denote a brackish marsh intermediate between fresh and salt. The GLO notes describe it as "open marsh," which is likely intended to describe freshwater marsh, because the GLO surveyors commonly used "saltmarsh" or "tide prairie" to describe saltmarsh. The 1914 County Assessor maps indicate "saltmarsh;" by then, the area would have gone through a history of draining and cultivation—the southern half of the marsh is shown as grassland in 1870, which could be cultivated land—and could possibly have undergone subsidence. In summary, while mapped as freshwater marsh in Figures 7 and 8, it could have been saltmarsh or intermediate between the two.

This coastal wetland (whether fresh or brackish) grades to the southeast into alder forest on the lower elevations of the older alluvial fan associated with the Gierin Creek DRP, and to the south the coastal wetland grades into a wetland complex in the lower elevations between this fan and the fan associated with the Dungeness River valley (see topography in Figure 4). This latter wetland complex, from which Cooper Creek originated, includes emergent and scrub-shrub vegetation, and is described in Appendix 1. It is largely coincident with an area of peat soil mapped on the County Assessor maps and on more recent geologic mapping (e.g., Schasse and Logan, 1998).

Graysmarsh and Washington Harbor

Figure 7 shows a total of 129 hectares of saltmarsh in the greater Dungeness area, and over half of this (67 hectares, or 52%) was in Graysmarsh. The remaining area was divided among the Dungeness River (17 hectares, or 13%), Washington Harbor (17 hectares, 13%), Dungeness Spit (13 hectares, 10%), and Cline Spit (3 hectares, 3%). The extent of Graysmarsh in Figure 7 is essentially unmodified from the T-1169 (surveyed in 1870 along with T-1168). Wetlands mapped adjacent to Graysmarsh to the east include a "cedar swamp," shoreward from which is a wetland mapped as freshwater, but which also could have been a saltmarsh component of Graysmarsh (see Appendix 1 for detail). Showing no map evidence of having been altered in the settlement period, the Washington Harbor lagoon, barrier spits, and associated saltmarsh were drawn directly from USC&GS T-1169.

Dungeness River Valley and Holocene paleochannel surfaces

As indicated earlier in the "methods" section, the Dungeness River shown in Figure 7 was taken with few modifications from the 1914 Clallam County Assessor Maps, in the absence of an earlier map depiction. The location of tributaries to the river—primarily Matriotti Creek and its tributaries—was drawn from a combination of 1942 and 1963 photographs, lidar, the 1914 Assessor maps, and the GLO plat maps and field notes. The positional certainty (and in some cases presence or absence) of Matriotti Creek and its network of tributaries varies. Additionally, the earliest aerial photographs (1942) appeared to show scrub-shrub and forested wetlands along parts of Matriotti Creek in the Dungeness River valley, but were too difficult to interpret on the grainy photographs and lacked corroborating information from the GLO notes, and so are not shown in Figure 8.

The Bell Creek and Gierin Creek valleys, currently sites of forested wetlands, both included large freshwater wetlands, in both cases described by the cadastral surveyors as "cedar swamp." The large wetland in the Bell Creek DRP also included an "open grass swamp" (see Appendix 1 for detail). Figure 7 does not show Bell Creek emerging from swamp at the base of Bell Hill. The GLO plat maps do not continue the channel past that wetland, and the line notes from surveys that crossed the Sequim Prairie in a north-south direction do not mention a creek. Figure 7 does show a very small creek draining the wetlands in the Bell Creek DRP; this channel was mapped from topographic traces visible on lidar; there likely were other very small creeks within the wetland complex.

Prairies

The largest two prairies in the greater Dungeness area were the Sequim Prairie (751 hectares, including two woodland inclusions totaling 70 hectares) and a prairie on a bluff overlooking the

Dungeness River and in which the first settlers established the original town of Dungeness (123 hectares). Figure 7 also shows several smaller prairies scattered throughout the area; see Appendix 1 for detail.

Most of the Sequim Prairie was described in GLO notes as “prairie” or “open prairie,” and it included two woodland areas described as having “scattering fir & oak timber” or “fir timber.” The Sequim Prairie graded into wetland on its eastern margin; it also included two small wetlands toward its northern edge, mapped from the County Assessor maps (Figure 7). Bearing trees (n=31) within the prairie confirm the dominance of very widely spaced fir. The average distance a surveyor traveled from his survey point to the nearest bearing tree—which provides an index of forest density—for all bearing trees in the greater Dungeness River area was 14.9 m. The average distance to firs in particular in forests on the three different age surfaces was 7.1 m on recent alluvium, 9.2 m on older alluvium, and 14.0 m on glacial sediments. In contrast, the average distance to firs within the prairie bearing trees was 50.9 m. Oak, presumably garry oak (*Quercus garryana*), was the second most common bearing tree in prairies, where they averaged 18 cm (7.1 inches) in diameter. Oak trees were spaced more than twice as distant as fir trees; the surveyor walked 139.0 m to the nearest bearing tree that was an oak.

Forest characteristics

Forests throughout the greater Dungeness River area were overwhelmingly “fir,” which accounted for nearly three-fifths of bearing trees (58.9%, n= 178 of 304 total; see Figure 9). The fir identified by surveyors presumably refers to Douglas fir *(Pseudotsuga menziesii);* all common name used by surveyors, and the likely species they saw are given in Table 3. Forests on recent alluvium (the modern Dungeness River valley) were more diverse than on the higher surfaces, having significant amounts of alder (red alder, *Alnus rubra*), cedar (western redcedar, *Thuja plicata*), and hemlock (western hemlock, *Tsuga heterophylla*) (Figure 10).

Fir was well distributed throughout the study area's elevation range (Figure 11), but was more common on older alluvium and glacial sediments, where it accounted for 71% of bearing trees on both surfaces, than in recent alluvium, where fir accounted for 45% (Figure 10). Firs on average had a small diameter (Figure 11), averaging 11.2 cm (7.5 inches) ± 1.0 cm and having a median of 15 cm. (All dispersions about the mean reported in this section of the report represent one standard error.)

After fir, western redcedar and western hemlock were the second most abundant trees, accounting for 8.2% and 9.2% of all bearing trees, respectively (Figure 9). Cedar was distributed throughout the study area, and western hemlock was restricted to higher elevations (Figure 11). Western redcedar was the largest diameter tree in the study area, averaging 29.7 cm (11.7 inches) ± 4.1 cm (Figure 11; n= 25, median = 24). Like fir, western hemlock was generally small in diameter, averaging 11.2 cm (4.4 inches) ± 1.1 cm (n=26, median = 10 cm). Spruce (Sitka spruce, *Picea sitchensis*), the only other conifer used as a bearing tree, was not abundant, accounting for 1.6% (n=5) of bearing trees (Figure 9).

As indicated previously, the Dungeness River was not "meandered," meaning that the immediately stream-side trees were not characterized, so that the information provided by bearing trees described above can't specifically be related to the immediate streamside area. Immediately streamside trees elsewhere in the region would have included many more deciduous trees than forests not immediately streamside (Collins et al. 2003). However bearing trees provide a means for assessing the trees that would most commonly provide large wood to the Dungeness River. Keeping in mind that (a) the data are biased toward conifers—specifically, it is likely that the Dungeness River corridor included many cottonwoods, as it does at present—and (b) the abundance of different conifer species in immediately streamside trees may differ from those outside the streamside area, the following can be concluded about coniferous species likely to have provided large wood to the Dungeness River. Of the 304 bearing trees within the study area, 41 fir and 10 cedar were 30 cm or more in diameter. Of these, 7 cedar and 6 fir were 50 cm or greater in diameter. This suggests cedar and fir were about equally likely to contribute very large (≥ 50 cm) wood to the river, and fir was four times more likely than cedar to contribute large (≥ 30 cm) pieces.

Table 3. Diameter statistics of bearing trees in the Dungeness River study area. The sample includes all trees in the study areas (e.g., immediately streamside, in valley bottom forests, and wetlands). Species are listed by decreasing frequency. "Fir" may include other species than Douglas fir.

USAGE IN GLO NOTES	PROBABLE TREE SPECIES	N	MIN (CM)	MAX (CM)	MEAN (CM)	MEDIAN (CM)
Fir	Douglas fir *Pseudotsuga menziesii*	179	4	100	19.3	15
Hemlock	western hemlock *Tsuga heterophylla*	28	4	30	11.2	10
Alder	Red alder *Alnus rubra*	26	3	50	14.2	10
Cedar	western redcedar *Thuja plicata*	25	8	80	29.7	24
Willow	Willow spp. *Salix spp.*	18	3	12	7.7	7
Maple	Bigleaf maple *Acer macrophyllum*	10	10	60	20.7	17
Oak	Garry oak *(Quercus garryana)*	6	8	24	15.3	15
Spruce	Sitka spruce *Picea sitchensis*	5	10	60	26.4	18
Cottonwood	black cottonwood *Populus trichocarpa*	3	8	16	13	15
"Laurel"	Unknown	1	--	--	24	24
Crabapple	Pacific crabapple *Malus fusca*	1	--	--	10	10
Elder	Elderberry *Sambucus racemosa*	1	--	--	8	8

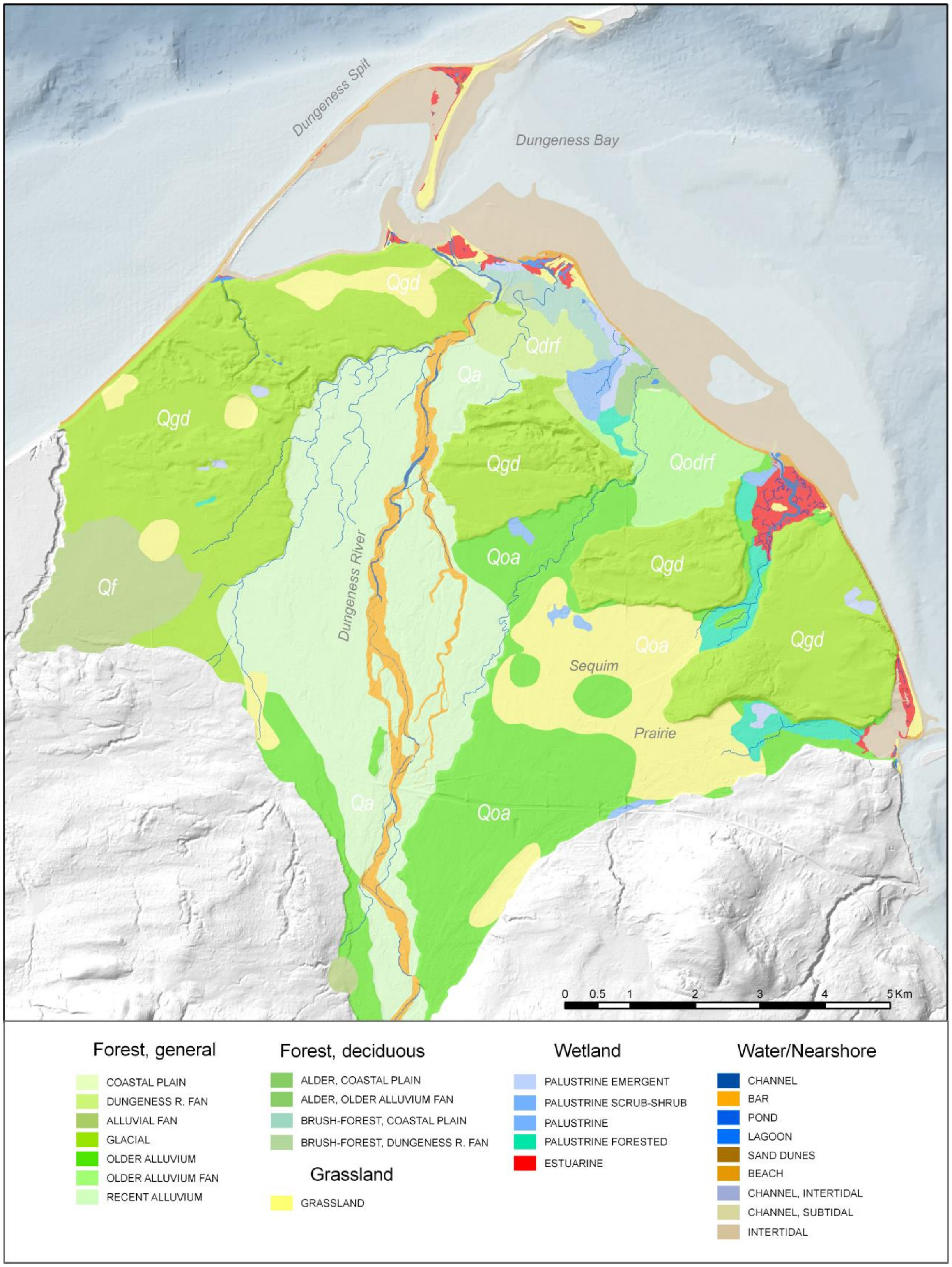


Figure 7. The greater Dungenesss River area landscape reconstructed for approximately 1850. See Figure 8 for detail in nearshore areas.

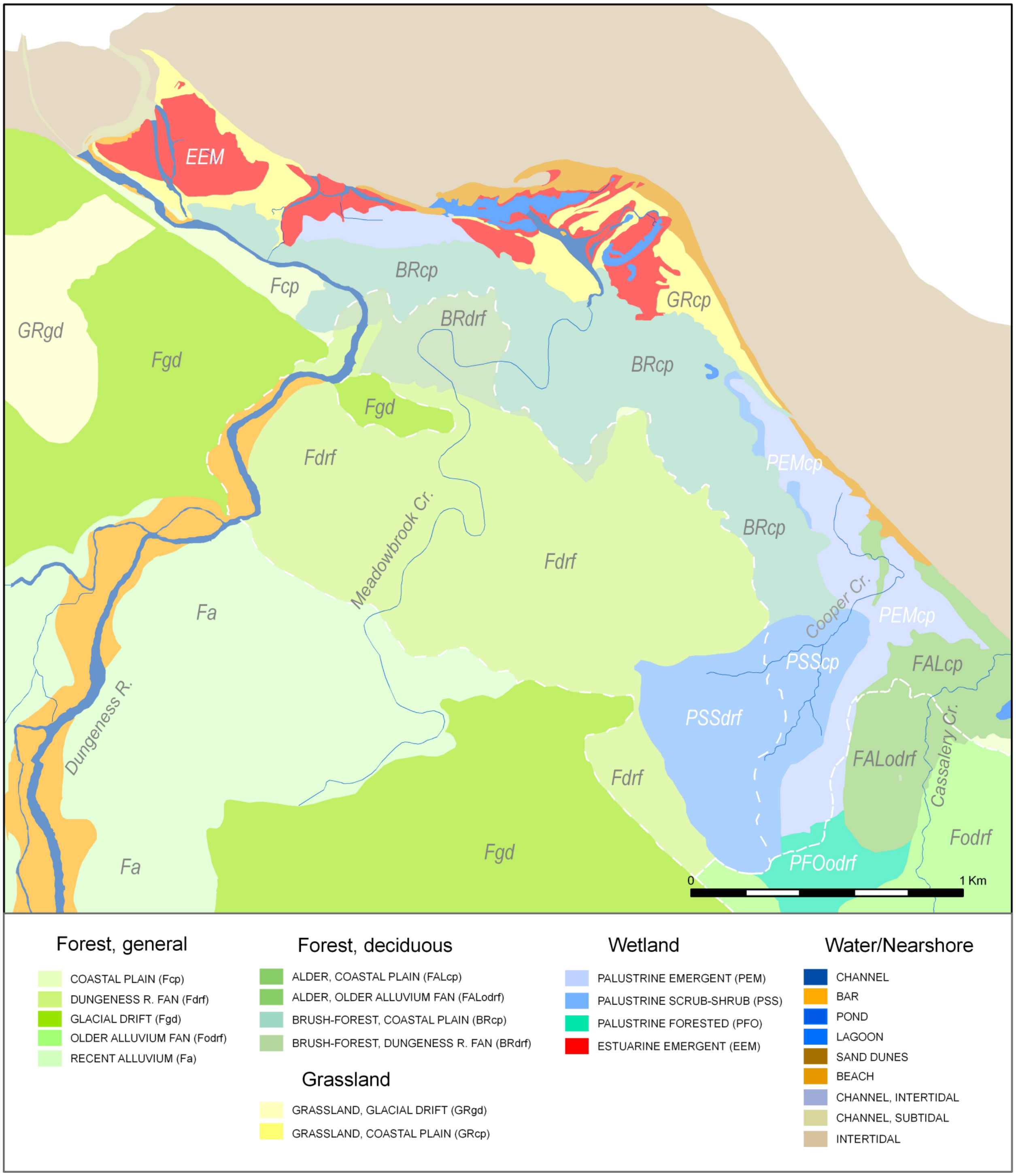


Figure 8. Close up of Figure 7, focusing on the coastal plain, from the historical Dungeness River estuary to Graysmarsh. Dashed white lines show approximate extent of Dungeness River fan (Qdrf in Figure 2) and the older Dungeness River fan (Qodrf in Figure 2).

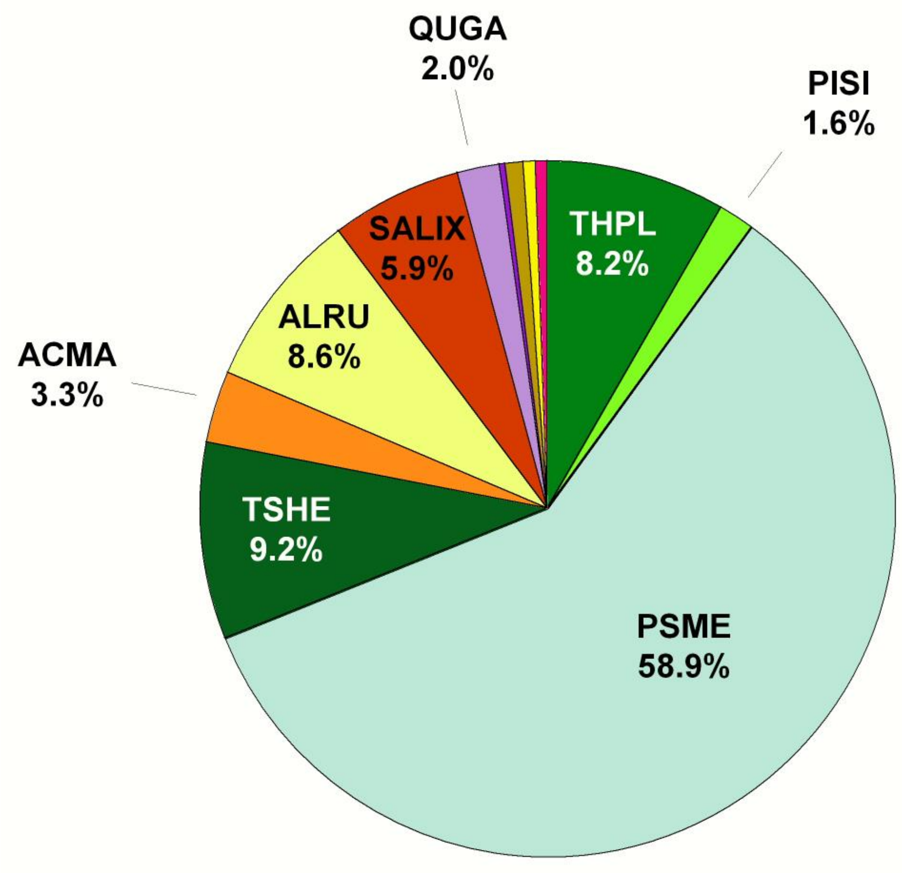


Figure 9. Frequency of bearing trees in General Land Office field notes (n = 304). THPL: *Thuja plicata* (western redcedar); PISI: *Picea sitchensis* (Sitka spruce); PSME: *Pseudotsuga menziesii* (Douglas fir); TSHE: *Tsuga heterophylla* (western hemlock); ACMA: *Acer macrophyllum* (bigleaf maple); ALRU: *Alnus rubra* (red alder); SALIX: *Salix spp.* (Willow species); QUGA: *Quercus garryana* (garry oak). Pie slices for species that account for less than 2% of bearing trees are not labled, and include: MAFU *Malus fusca* (Pacific crabapple), 0.3%, POBAT *Populus trichocarpa* (black cottonwood), 1.0%, SARA *Sambucus racemosa*, (Elderberry), 0.3%, and “Laurel” (species unknown), 0.7%.

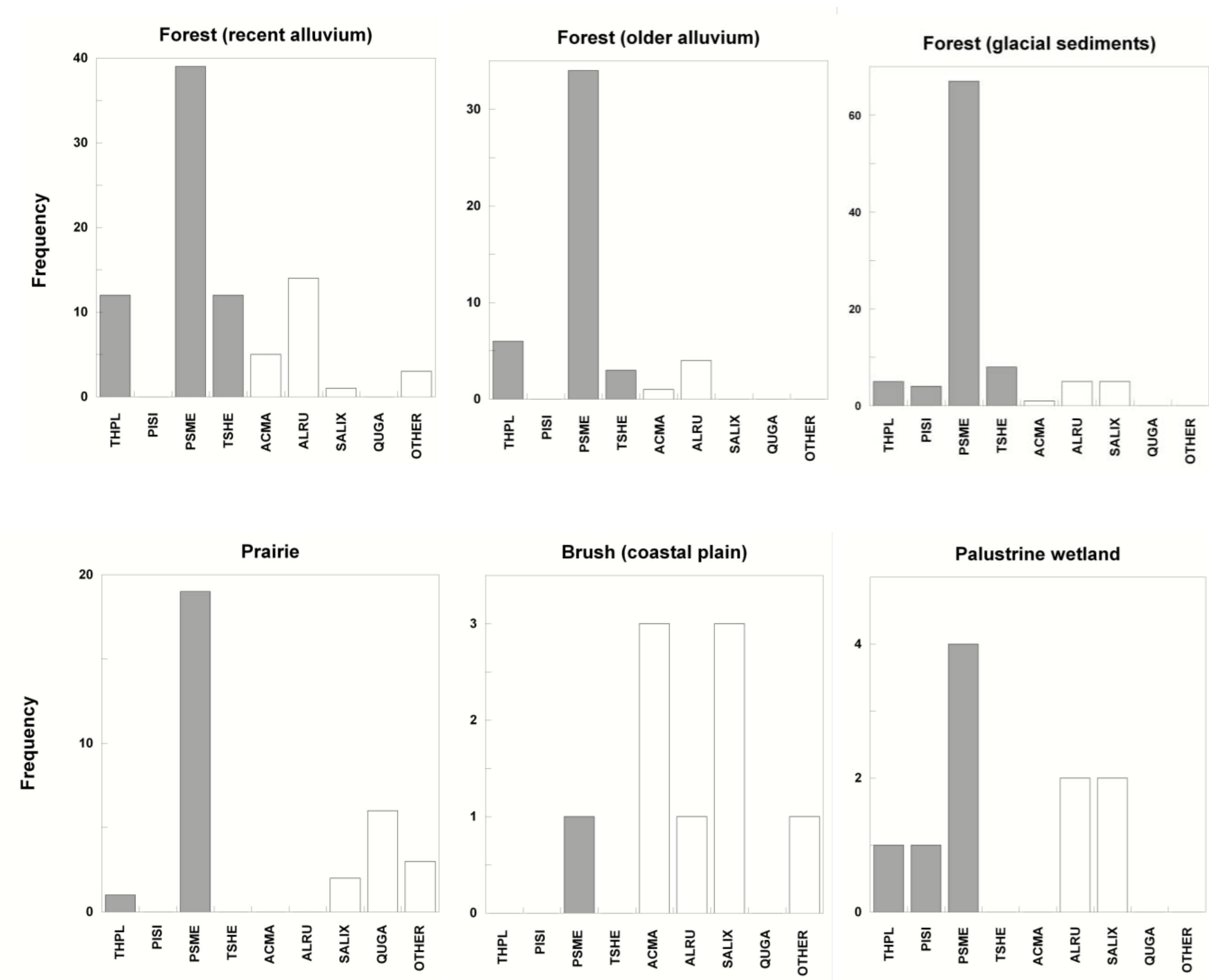


Figure 10. Frequency of bearing trees in General Land Office field notes, for six different land cover types. Dark bars are coniferous species and white bars are deciduous species. Species abbreviations are as in Figure 9. Other" includes: MAFU, POBAT, SARA, and "Laurel." Note that scale of y-axis varies between panels.

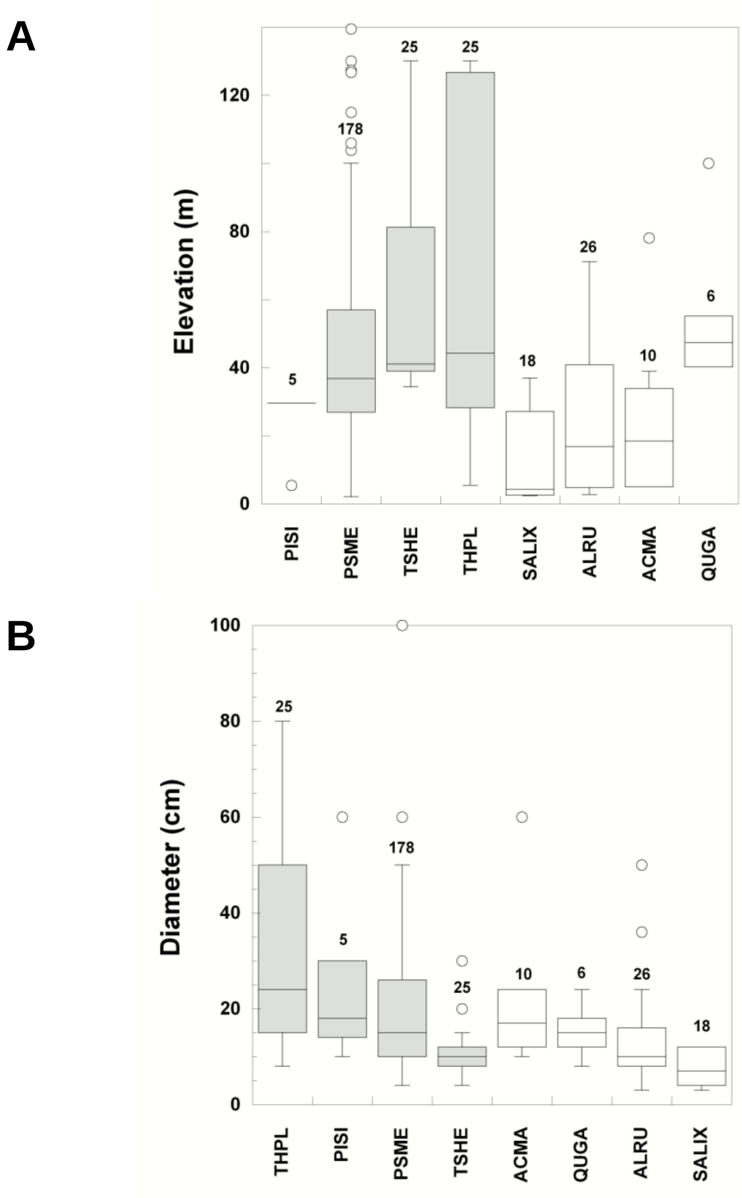


Figure 11. (A) Elevation and (B) diameter of bearing trees in the study area. Conifers have shaded bars. Numbers are sample size. Species abbreviations are as in Figure 9. Note that species order differs between panels A and B. Horizontal line within box represents median, and box encloses 50% of values. Lines extending from the top and bottom of boxes indicate minimum and maximum values, excepting outlier values (circles) greater than the inner quartile plus 1.5 times the inner two quartiles.

HISTORICAL CHANGE

Historical change to the Dungeness River area landscape reflects the interaction of land uses with ecological and physical processes. Among the land use changes are river diking and channelizing, flow diversion, land clearing, and wetland draining. Important physical processes in the nearshore area particularly include the dynamics between longshore sediment transport and deposition, and the fluvial transport of water and sediment.

Early settlement

The first settlers came to the Dungeness in 1851 (Keeting, 1976). Their settlement was concentrated on the coastal plain and on the large prairie on the glacial bluff to the west (the location of the original town of Dungeness), and associated with a few smaller prairies elsewhere to the west of the Dungeness River on the glacial upland (Figure 12).

Between 1858 and 1870 the Dungeness River channel avulsed to near its present location (see below for detail). Possibly the river's position in 1855-1859 reflected anthropogenic diversion; the river made a sharp leftward (northwestward) turn and cultivated fields were located in what would have been the more direct path to Dungeness Bay. However, those fields were within the land claim of B. I. Madison, who was among the first half-dozen settlers in 1851, and would have had the pick of land without having to resort to diverting the river to grow crops. Additionally, an Indian village was located along the Dungeness' 1855-1859 path, suggesting the river had been there for some time, and additionally the river had built a substantial delta associated with the 1855-1859 location, as described previously. Together these argue against the river's 1855-1859 location being the result of settlers' efforts. It's reasonable to consider that settlers could have influenced the river to avulse between 1859 and 1870 because of the coincidence in time with their second decade of settlement, but on the other hand the avulsion resulted in the river's taking the shorter path to the Bay, a natural deltaic process. A search for accounts by settlers could establish whether or not settlers influenced the river's location in the 1850s and 1860s.

An 1885 federal publication on tide marshes indicates that of the "several hundred acres" of tide marsh around the mouth of the Dungeness, Captain E. H. McAlmond had a tract of "60 or 70 acres, kept most of the time in grass for hay" (Nesbit, 1885; Nesbit's report used "tide marsh" to refer to any marsh, saltwater or freshwater, affected by the tides; see p. 5-6 in Nesbit's report). The federal report described this as the only "considerable tract of diked marsh" on the Strait of Juan de Fuca. This diking was likely subsequent to the 1855 USC&GS T-0539, which shows no diking. The diking may have occurred prior to (and potentially influenced) the river avulsion; Captain McAlmond first requested land claim to the area bordering the 1855-1859 river mouth in 1853 (Keeting, 1976), and the avulsion was between 1859 and 1870. By 1870 (T-1168 and T-1169), substantial amount of wetland along the coastal plain to the southeast of the Dungeness River had been drained and cultivated or pastured. The two T-sheets do not show sea dikes associated with this land conversion, other than those in the original Dungeness River delta.

The first settlers arrived in the Sequim Prairie in 1853, and by 1896 had opened the first irrigation ditch (Keeting, 1976). In the 18 years between 1896 and the detailed mapping in 1914 by the Clallam County Assessor, a dense network of irrigation ditches had been established, focusing in particular on the Sequim Prairie area (Figure 13). By the early 20th century, the greater Dungeness area landscape had been heavily modified (Figure 13A), although not densely settled; Figure 13B shows every structure noted by the Assessor's survey. A long dock into Dungeness Bay was completed in 1891 (Keeting, 1976) when the town of Dungeness was relocated to its present location from the bluff to the west.

The Dungeness River delta

As indicated above, the earliest (1855) mapping shows the river channel took a sharp westward turn at about the present-day location of the town of Dungeness and about 300 m downstream of the present-day Schoolhouse Bridge (Figure 14). One possibility for this sharp turn is that the river encountered sand accumulations that formed a topographic barrier, likely accreting in an east-to-west direction and deflecting the river to the west. A large saltmarsh was associated with the 1855 river delta. The marsh was bounded by a large sand spit; located about 600 m westward of the present-day mouth, the spit extended about 500 m outward from the present-day shoreline (Figure 14).

By 1870, the channel had broken through to the north, taking a straighter path to the Bay (Figure 14). The outer limit of the channel and the delta was about 500 m inland from the 2003 river mouth (Figures 14 and 15). The first bulkhead shown on a published map appears in 1870 on the left (west) bank extending downstream for about 300 m from the present day location of Schoolhouse Bridge (Figure 16). To the west, saltmarsh surrounding the former 1855 river mouth was diked sometime after 1855; the 1870 map does not cover the area, and dikes had been built by the 1907 map and previous to the federal report (Nesbit 1885) on tidal marshes.

As a consequence of the river having avulsed from its 1855 location to the 1870 location, the sand spit associated with the 1855 mouth gradually was deflected westward and landward, so that by 1963 the former sand accumulation was entirely absent. Since 1963, this shoreline location and form has remained approximately the same (Figure 15).

Meanwhile, the 1870-onward delta accreted outward, toward the northwest, presumably deflected in this direction by the effects of westward longshore sediment transport. A prominent spit also accreted outward and to the west (Figure 15), creating a form very similar to the spit at the 1855 mouth, and the spit at the mouth of the Meadowbrook Creek DRP in 1855 (Figure 6 and Figure 23). These three characteristic spits were presumably created by the longshore transport of sediment augmented by fluvial sediment from the Dungeness River, formed and maintained as spits separated from the mainland by the outward deflecting force of fresh water from the river.

From 1870 to 1942, a distributary branch of the river, locally known as Meadowbrook Slough, diverged and flowed eastward. Since at least the 1914 map and possibly the 1907 map, Meadowbrook Creek has been tributary to the slough. Right-bank bulkheads appeared in different location on the 1907 USC&GS map, and the 1914 Clallam County Assessor's maps (Figure 16), presumably in part to block this flow from leaving the Dungeness River. Flow to this channel appears to have been closed in the 1907 map. From 1907 to 1942, it flowed in a broad arc westward to rejoin the main channel (Figure 14); since then it has sometimes entered saltwater at a separate mouth, and sometimes rejoined the Dungeness River (Figure 17). The Meadowbrook Slough was closed again in 1963, except for a small culvert, by a levee built by the Army Corps of Engineers (Figures 16 and 17). This east distributary continued to exist as a tidal channel having an estuary created by the continued westward accretion of the delta's sand spit (Figure 17); the channel was shortened when the Dungeness River breached the barrier spit (bracketed by 1994 and 1995 photos). Coastal erosion bracketed by the 1998 and 1999 photos breached the channel, creating the outlet that now exists about 400 m east of the 1995 outlet and about 600 m east of the 1994 outlet (Figure 17). The remnant of the east distributary's former channel and estuary since then has been a lagoon open to varying amounts of tidal flow to the west (Figure 17).

In the early 1970s (bracketed by 1972 and 1975 aerial photographs) a channel was built to allow more flow to exit into the estuary of the east distributary (Figure 17). Water flowed out this route historically, from 1870 through 1926 as the mainstem; in the 1942 and 1963 photos, only a small amount flowed into the upper end of a narrow tidal slough (see 1942 photo panel in Figure 17). The channel constructed between 1972 and 1975 was supplemented with a levee on its right bank side (Figures 16 and 17). However, by 1975 nearly all of the river's flow had switched to the built channel, greatly enlarging it. In the decades that followed, flow to the formerly-dominant mouth (labeled "1914-2002" in Figure 14) declined, the channel narrowed substantially, and appeared dry in the 2000 aerial photographs.

Most recently, (between 2001 and 2002), the Dungeness River breached through the sand spit that had been growing gradually outward and westward since 1870, creating an island from the former tip of the spit (Figure 17).

The shoreline in the former Meadowbrook Creek delta area, and the current location of Three Crabs Road, at the eastward margin of Figure 14, has undergone several changes in the last century and a half (Figure 18; see also later, Figure 23). In 1855 and 1870, a barrier sand spit accreted westward, being maintained as a spit by the flow from Meadowbrook Creek, and, as discussed previously, probably water from the Dungeness River in the not-distant past. By 1907, the Meadowbrook Creek estuary had closed, and the coastline has accreted outward from the 1870 location. The shoreline appears to have changed little by 1942. The dominant causes for the late 19th century disappearance of the Meadowbrook Creek delta estuary are speculative; it could represent the disappearance of a "fossil" estuary that might have formed earlier by greater flows when Meadowbrook Creek was augmented by Dungeness River flow, and it could reflect some influence of early development, including the Dungeness Pier.

The start of a second series of changes in the former Meadowbrook Creek delta area is evident in the 1963 photograph, longshore sand has begun to accrete from the east, which continues throughout the remainder of the photo series. This accumulation begins to take the form of a spit in 1985, which by 2000 has begun to "collapse," or fold inward at its down-drift western end. By 2003 the western end of the former spit has completely merged with the shore, creating a closed lagoon.

Figure 19 shows the rate at which land at the delta accreted and eroded, and the net change, for eight time periods between 1855 and 2003 (see Table 4 for data). Shoreland area increased the most in the 1914-1926 period, after which the rate of increase diminished to essentially no change in the 1975-1990 and 1990-2003 periods (net accretion of 0.04 hectares/year in 1975-1990 and net loss of 0.06 hectares/year in 1990-2003); overall there was a gain of 32.6 hectares between 1855 and 2003). Relating these numbers directly to the modern Dungeness River delta is complicated by their pertaining to the extended coastal area of Figure 15. Focusing only on the modern delta, Figure 21 shows shoreland change resulting from shoreline change since 1942 (Figure 20). Figure 21 shows a net increase in shoreland between 0.05 and 0.26 hectares/year between 1942 and 1985, and then a net shoreland loss from 1985-1990 and 1990-2003, when the loss averaged -0.14 and -0.29 hectares per year, respectively (Table 5). The total increase in land area in the 61 years from 1942 to 2003 was 4.3 hectares.

The lower Dungeness River and greater Dungeness nearshore to Washington Harbor

The Dungeness River's riparian corridor corresponds roughly to the extent of the active channel (i.e., low flow channel and high flow channel) shown on the 1914 County Assessor maps (Figure 21). Levees constrict the river to a portion of the riparian corridor, primarily on the left bank (west) side (Figure 22).

The mid-19th century condition of the Meadowbrook Creek estuary/delta was described previously in this report. The maps and photographs in Figure 23 depict change between 1855 and 2001. Figure 24 also shows the history of land use modifications to the coastal plain; the primary effects were draining wetlands and channeling creeks.

While there have been artificial changes to its hydrology, Graysmarsh is relatively unchanged in its morphology. This is presumably in part because the estuary is within a former marine embayment, which is a lower energy environment than the fan on which Meadowbrook Creek and Dungeness River estuaries are formed; it does not protrude into marine waters, as the other two fans do, instead being inset between two upland or higher terrace surfaces, and Gierin Creek has neither a high sediment load nor high stream energy. The estuary is also within a zone of diverging nearshore drift, in contrast to the other two estuaries, which are within a directional drift cell in a high-energy marine environment. These two differences in landscape setting and in marine conditions probably account for the relative morphological stability. Figure 25 shows the history of modifications to Graysmarsh. By 1914, tidal channels had been straightened and the network simplified, the tidal prism reduced to a culverted entrance on the marsh's southeast margin, and the western part of the marsh drained and cleared; subsequent maps and photographs show continued drainage modification.

Marsh fringing Washington Harbor on the mainland (to the west and south of the harbor) was diked and drained by the early 20th century (Figure 26). Roads were built on Gibson's Spit and the spit on the south side of the harbor's entrance by 1914, and by 1954 a road had been built across the harbor to Gibson's Spit, partially limiting tidal flow to the northern portion of the lagoon (Figure 26).

Implications for Restoration

Historical reconstructions such as the one presented in this report contribute to establishing an historical "reference condition" by providing insight into earlier landforms and habitats, and the processes that shaped them. Such a reconstruction has limitations. For example, carried out at a landscape scale, it cannot substitute for site-scale investigations. Additionally, interpreting historical conditions involves considerable inference; parts of such a reconstruction have lower certainty than others, or are incomplete, and probably in some cases completely wrong. Users of interpretations such as this one are advised to examine the sources, logic, and inferences used to reconstruct individual features or to make broad inferences, and to keep in mind that the reconstructions are at a landscape scale.

Historical reconstructions provide insight into how different parts of the landscape respond to different land uses and engineering measures. They also can point to the particular processes or functions critical to restoring different environments. In some parts of the landscape, landforms and the physical template remain unchanged on a broad scale, and restoration would focus on restoring the hydrologic regime and the natural channel network (e.g., Graysmarsh). Or, essential hydrological and physical processes have not been grossly changed but the amount of space in which they can operate has been restricted, and eliminating or reducing that physical restriction is the focus (e.g., diking of the lower river). Elsewhere, landforms have changed essentially irreversibly owing to sediment deposition (the Dungeness River delta) or the loss of freshwater inflow owing to natural river avulsion (e.g., the Meadowbrook Creek delta); restoration in these contexts cannot reasonably involve a return to a previous status, but can focus on restoring natural processes in the context of the changed landforms.

Table 4. Change in land area in area shown in Figure 15. Data are displayed graphically in Figure 19.

Time period	Area change (hectares)			Average annual area change (hectares/year)			
	Accretion	Erosion	Net change	Years	Accretion	Erosion	Net change
1855-1907	15.08	-7.78	7.30	52	0.29	-0.15	0.14
1907-1914	5.66	-6.40	-0.75	7	0.81	-0.92	-0.11
1914-1926	12.64	-1.73	10.91	12	1.05	-0.14	0.91
1926-1942	9.76	-2.67	7.10	16	0.61	-0.17	0.44
1942-1963	7.73	-4.68	3.05	21	0.37	-0.22	0.15
1963-1975	6.94	-1.64	5.31	12	0.58	-0.14	0.44
1975-1990	3.33	-2.81	0.52	15	0.22	-0.19	0.04
1990-2003	4.59	-5.42	-0.83	13	0.35	-0.42	-0.06

Table 5. Change in land area in area shown in Figure 20. Data are displayed graphically in Figure 21.

Time period	Area change (hectares)			Average annual area change (hectares/year)			
	Accretion	Erosion	Net change	Years	Accretion	Erosion	Net change
1942-1963	5.67	-0.17	5.50	21	0.27	-0.01	0.26
1963-1975	3.27	-0.51	2.76	12	0.27	-0.04	0.23
1975-1985	1.42	-0.91	0.51	10	0.14	-0.09	0.05
1985-1990	0.92	-1.60	-0.68	5	0.18	-0.32	-0.14
1990-2003	0.79	-4.58	-3.80	13	0.06	-0.35	-0.29

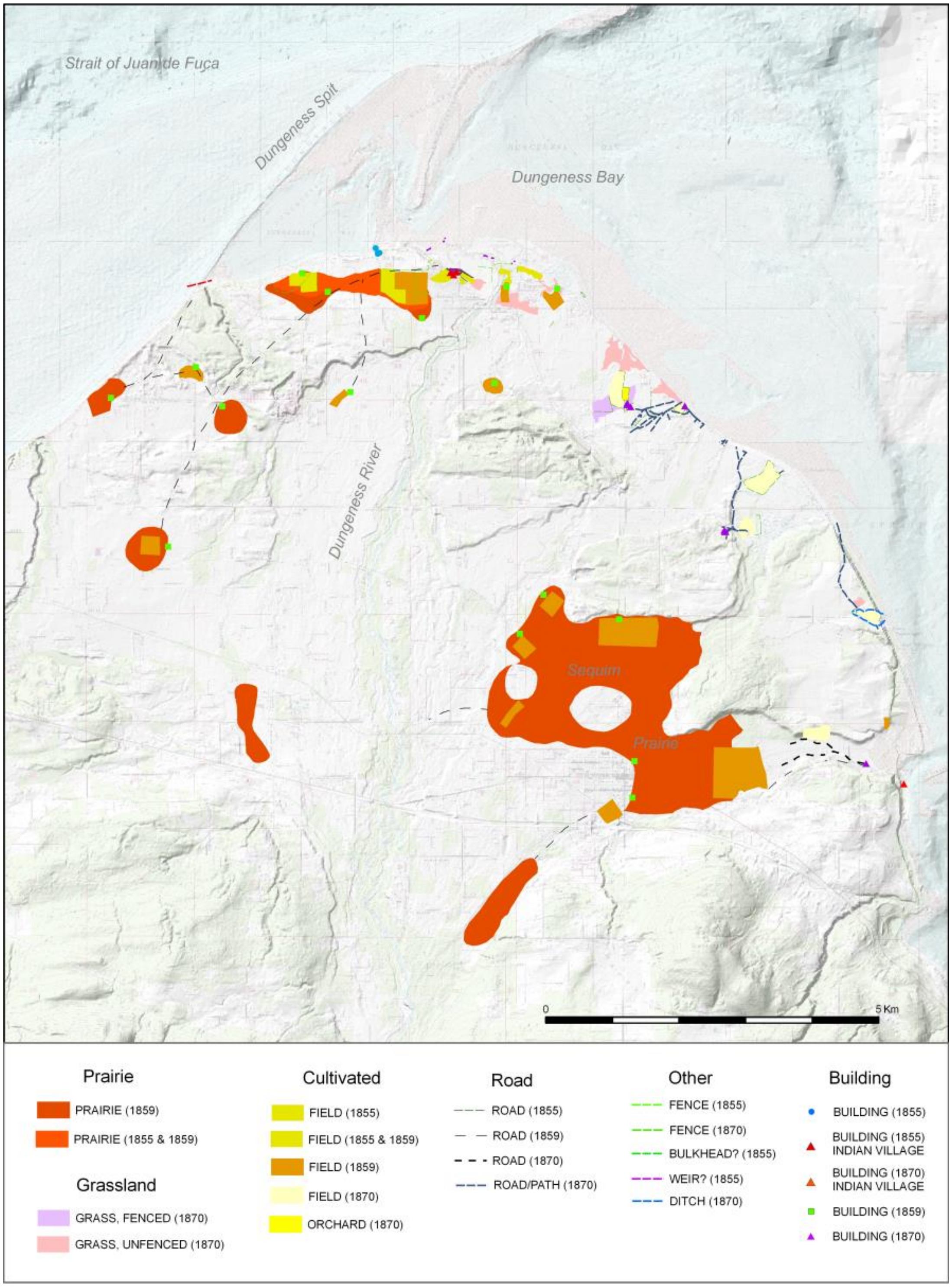


Figure 12. Early settlement (1855-1870) in the greater Dungeness River area from USC&GS and GLO map sources (see Table 1). Background is recent USGS topographic map.

A

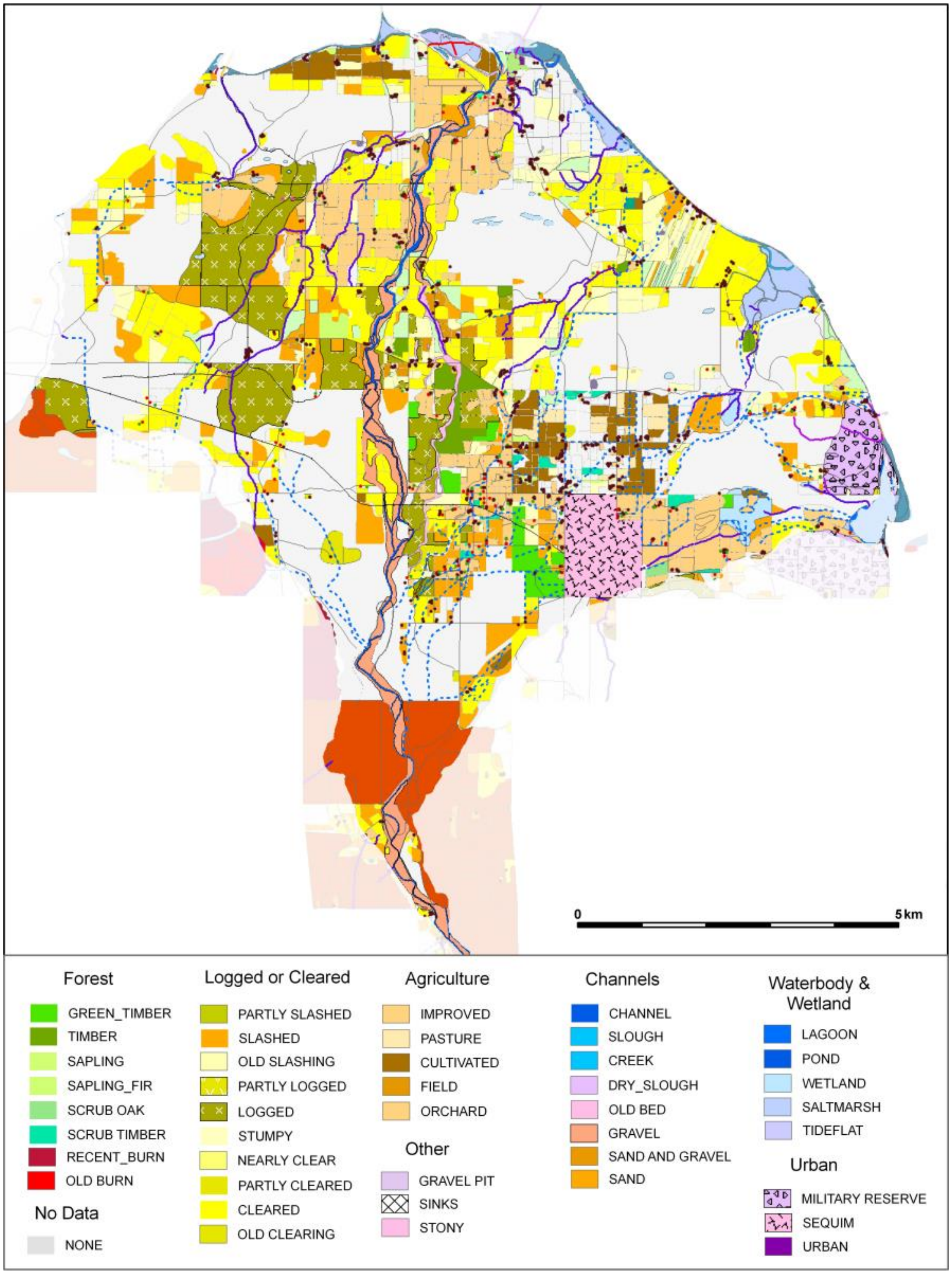


Figure 13 (continued on following page). Land use and land cover shown on 1914 Clallam County Assessor maps. Panel B extracts line and point data from Panel A.

B

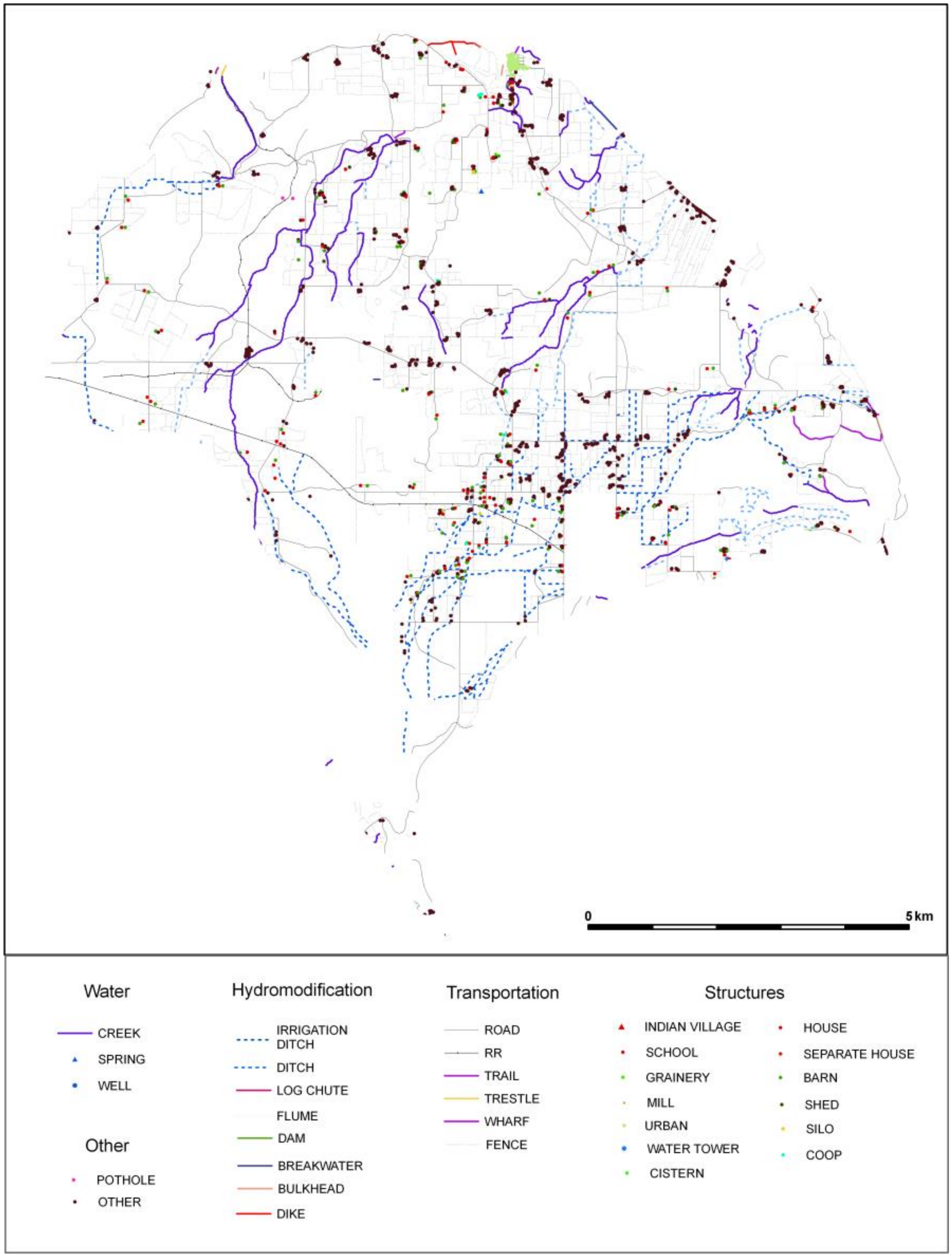


Figure 13 (continued from previous page). Land use and land cover shown on 1914 Clallam County Assessor maps. Panel B extracts line and point data from Panel A.

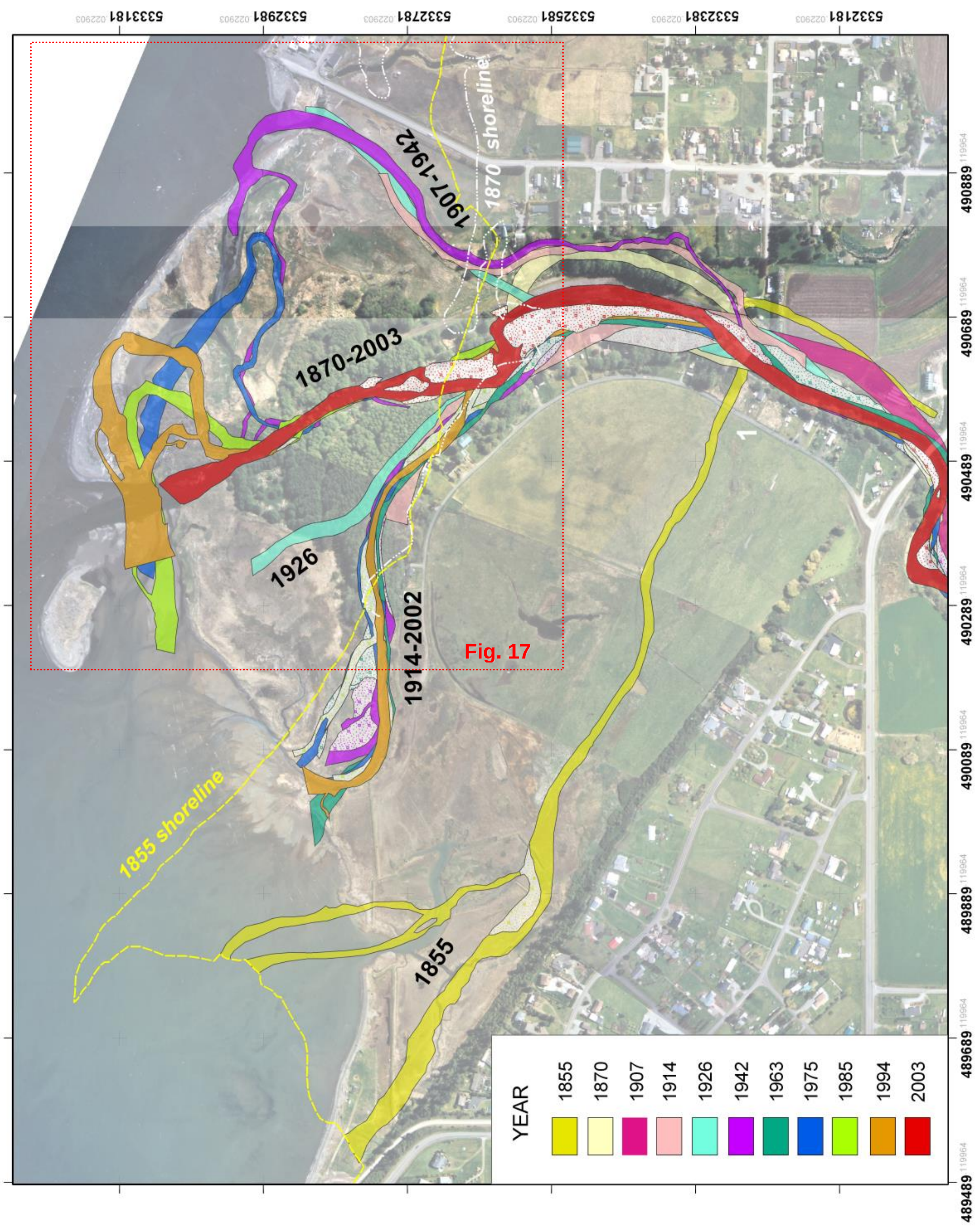


Figure 14. Channel locations, 1855-2003. Channel was mapped from maps (1855, 1870, 1907, 1914, 1926) and aerial photographs (1942, 1963, 1975, 1990, 2003). Background is 2003 color aerial photography. Graticule is UTM North and ticks are every 500 m. Red box outlines extent of Figure 17.

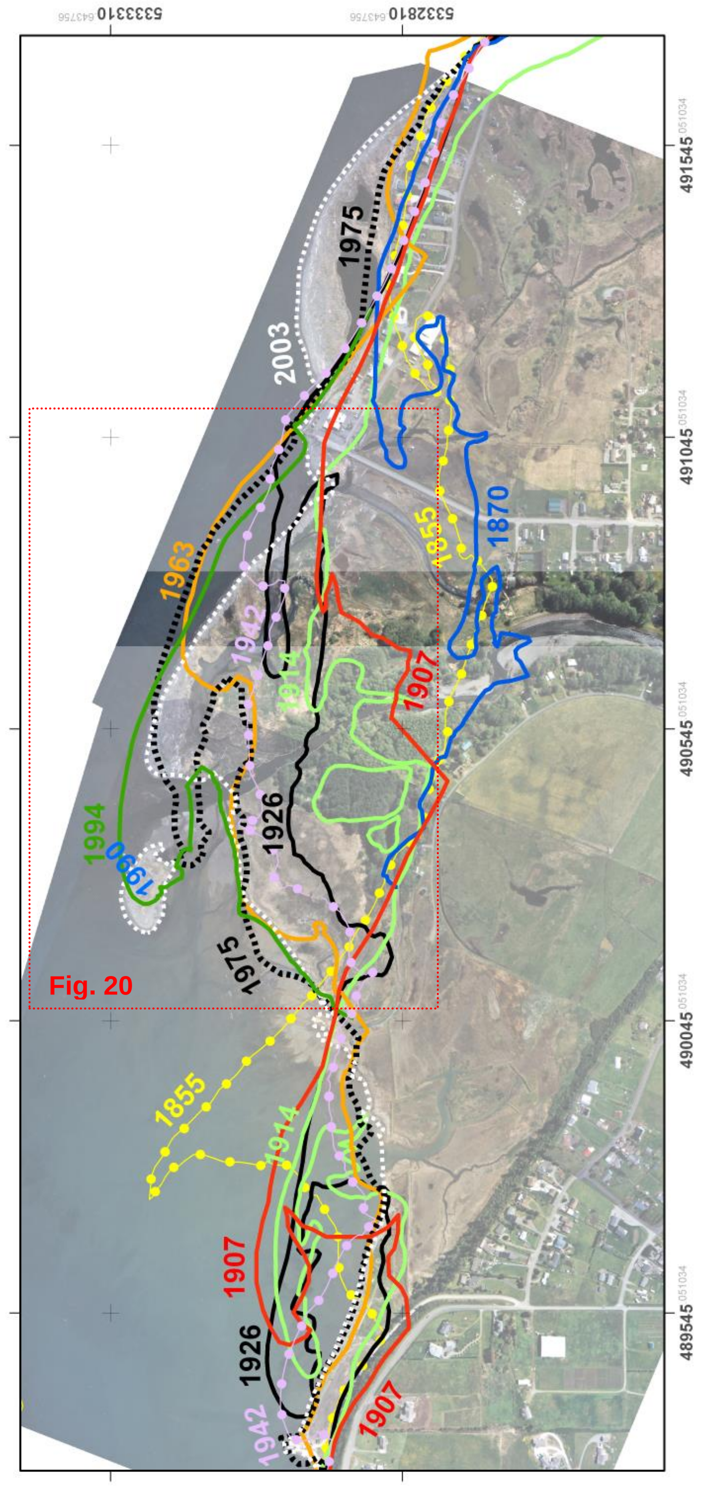


Figure 15. Shoreline locations, 1855-2003. Shoreline was mapped from maps (1855-1926) and aerial photographs (1942-2003). Background is 2003 aerial photography. Graticule is UTM North; ticks are every 500 m.

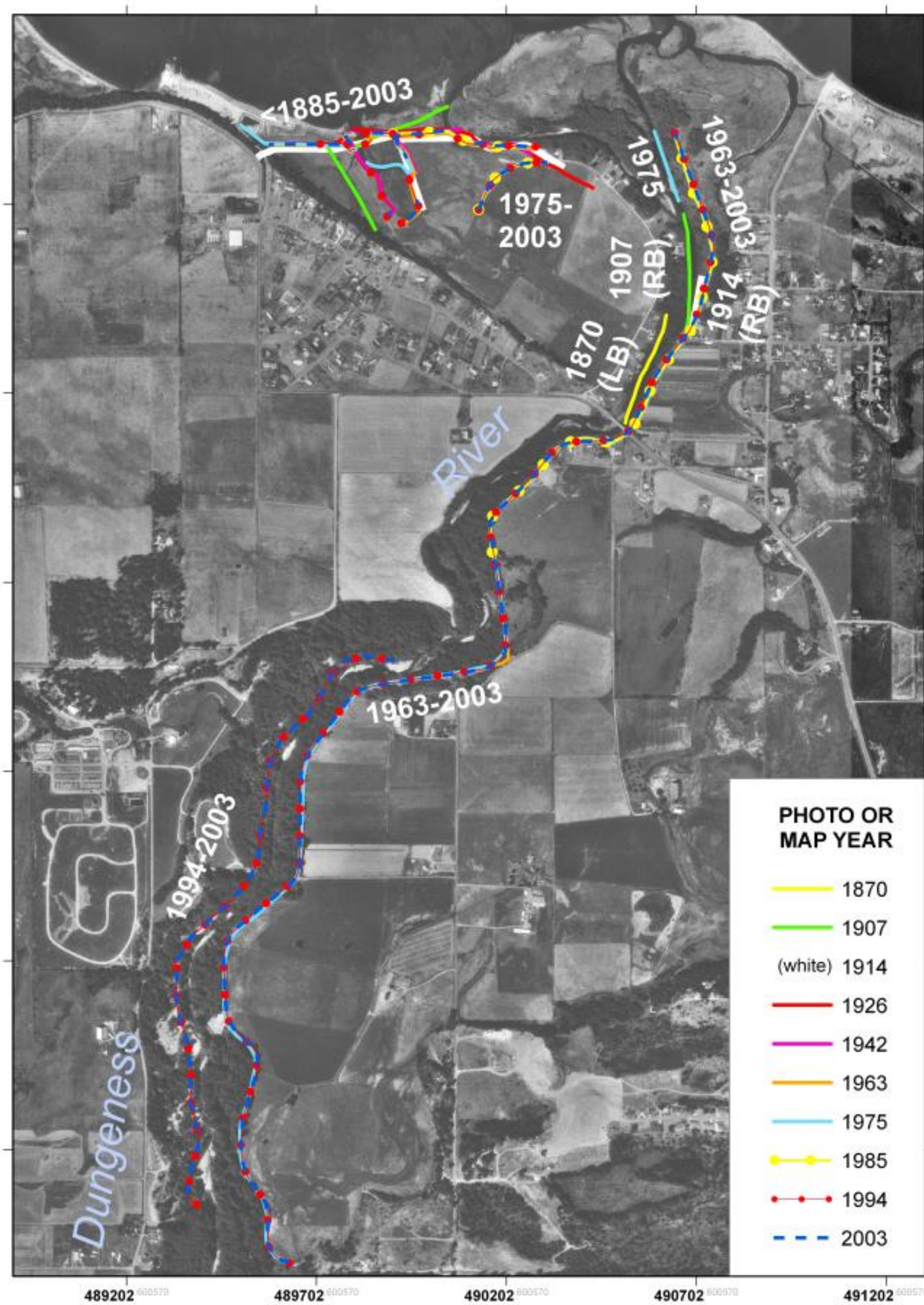


Figure 16. River levees along the lower Dungeness River, 1870-2003. Base photo is 1990 USGS DOQQ.

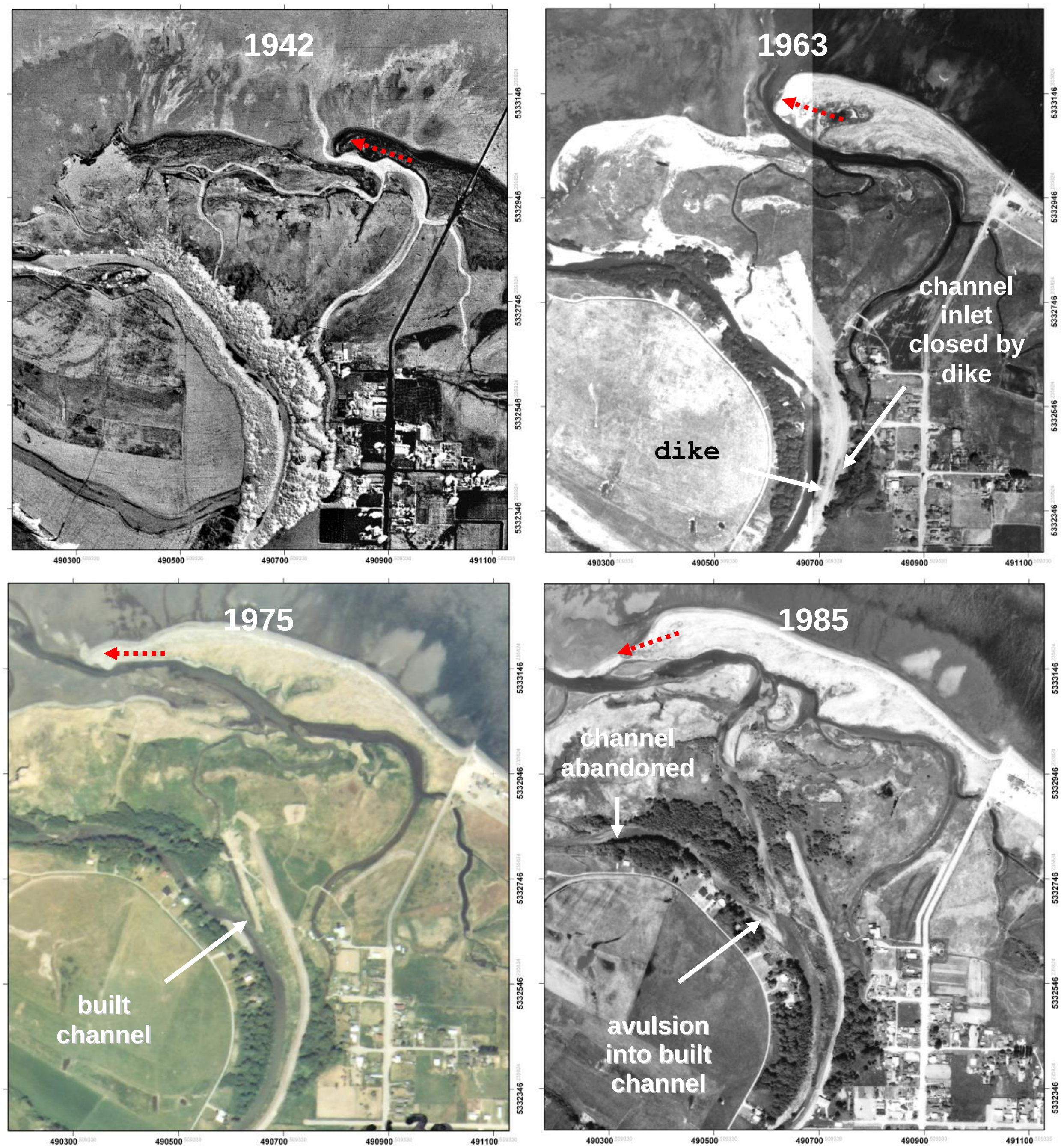


Figure 17 (continued on following page). Detail of channel changes shown in Figure 14. 1963: Barrier spit has continued to accrete westward. Army Corps dike built in 1963 sealed off east distributary channel. 1975: Continued spit accretion creates wider estuary. Artificial outlet channel built between 1972 and 1975. 1985: Spit accretion continues westward and southwestward, narrowing estuary. River has avulsed into built channel, beginning process of abandoning west distributary channel.

Figure 17 (continued from previous page). Detail of channel changes shown in Figure 14. 1994: Barrier spit has continued to accrete westward. *1995*: Dungeness River breaches barrier spit between 1994 and 1995. *1999*: East distributary (a tidal channel since being diked in 1963) breached by coastal erosion between 1998 and 1999. River breaches barrier spit between 2001 and 2002.

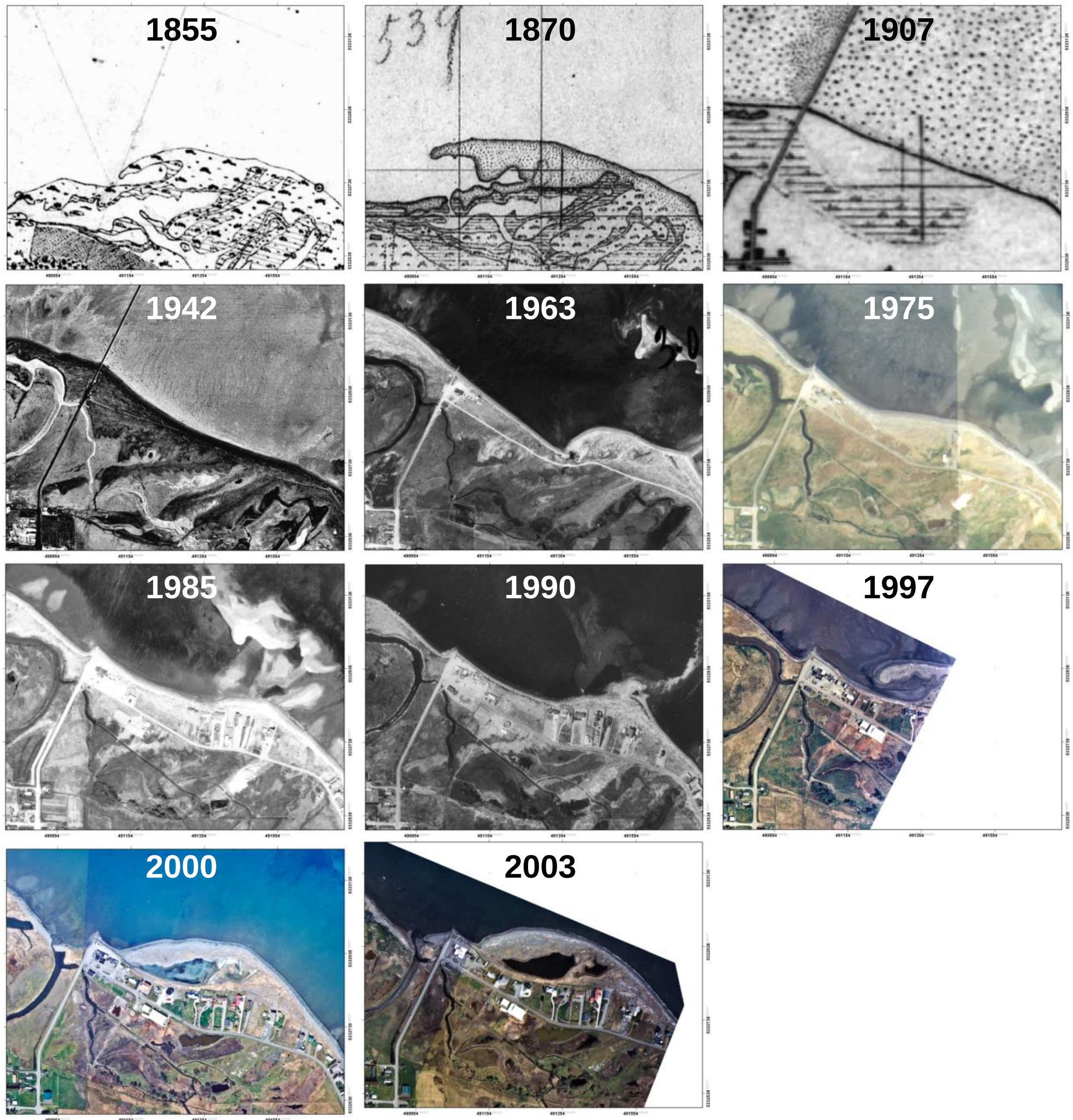


Figure 18. Coastal change at Meadowbrook Creek estuary and Three Crabs Road area, 1855 to 2003. 1855 to 1870, barrier spit for Meadowbrook estuary accretes westward. Outward accretion and closure of estuary creates a featureless coastline in 1907, which had changed little by 1942. Longshore sand starts to accrete from east by 1963, continuing outward and westward through 2003. Spit begins to form in 1985. Spit has nearly “collapsed” shoreward in 2000 and had closed around a lagoon by 2003.

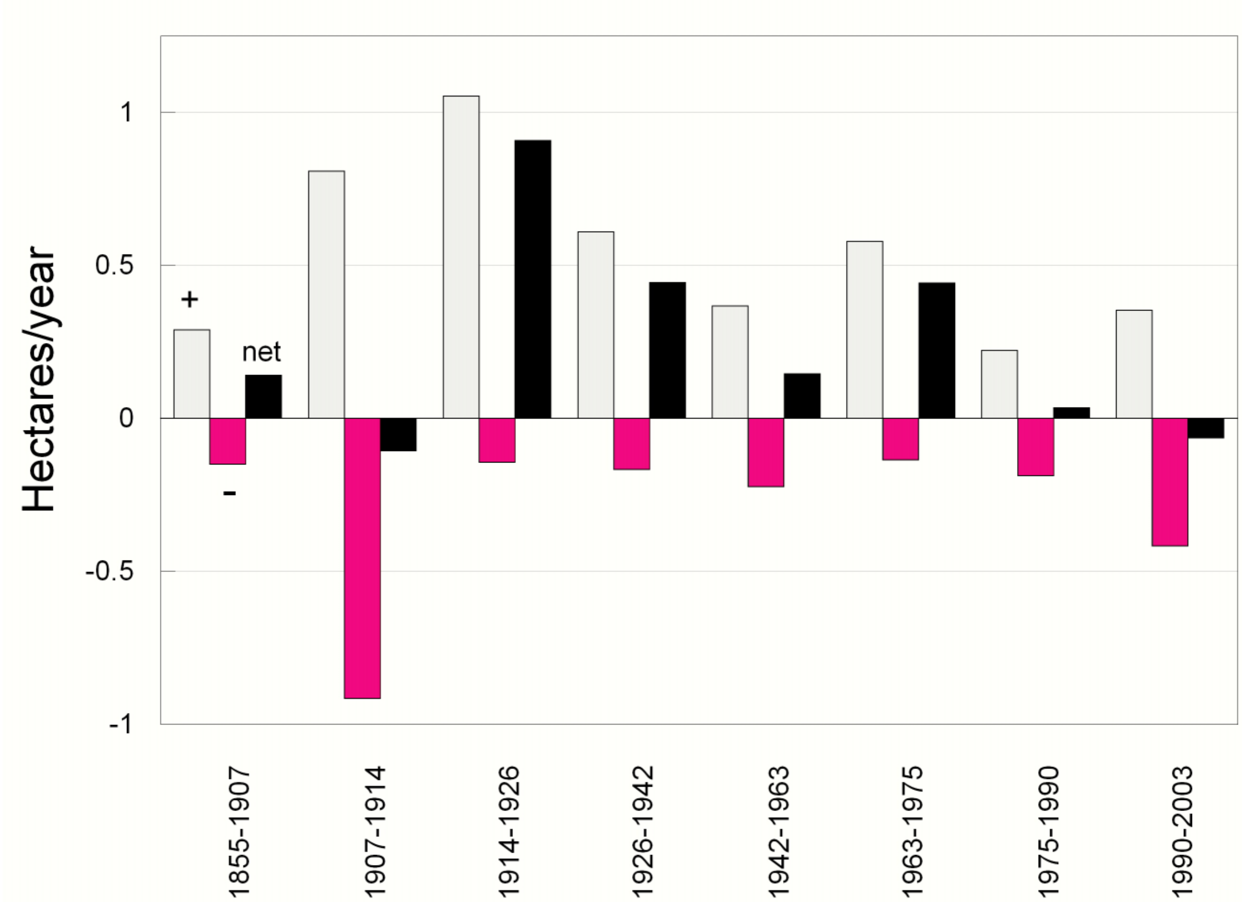


Figure 19. Accretion (gray bar), erosion (red bar) and net change (black bar) of land within the extent of Figure 15, for eight time periods from 1855 to 1903. Change is averaged over each time period and expressed as hectares per year. Data were created using the shorelines shown Figure 15, from maps (1855, 1907, 1914, 1926) and aerial photographs (1942, 1963, 1975, 1990, 2003).

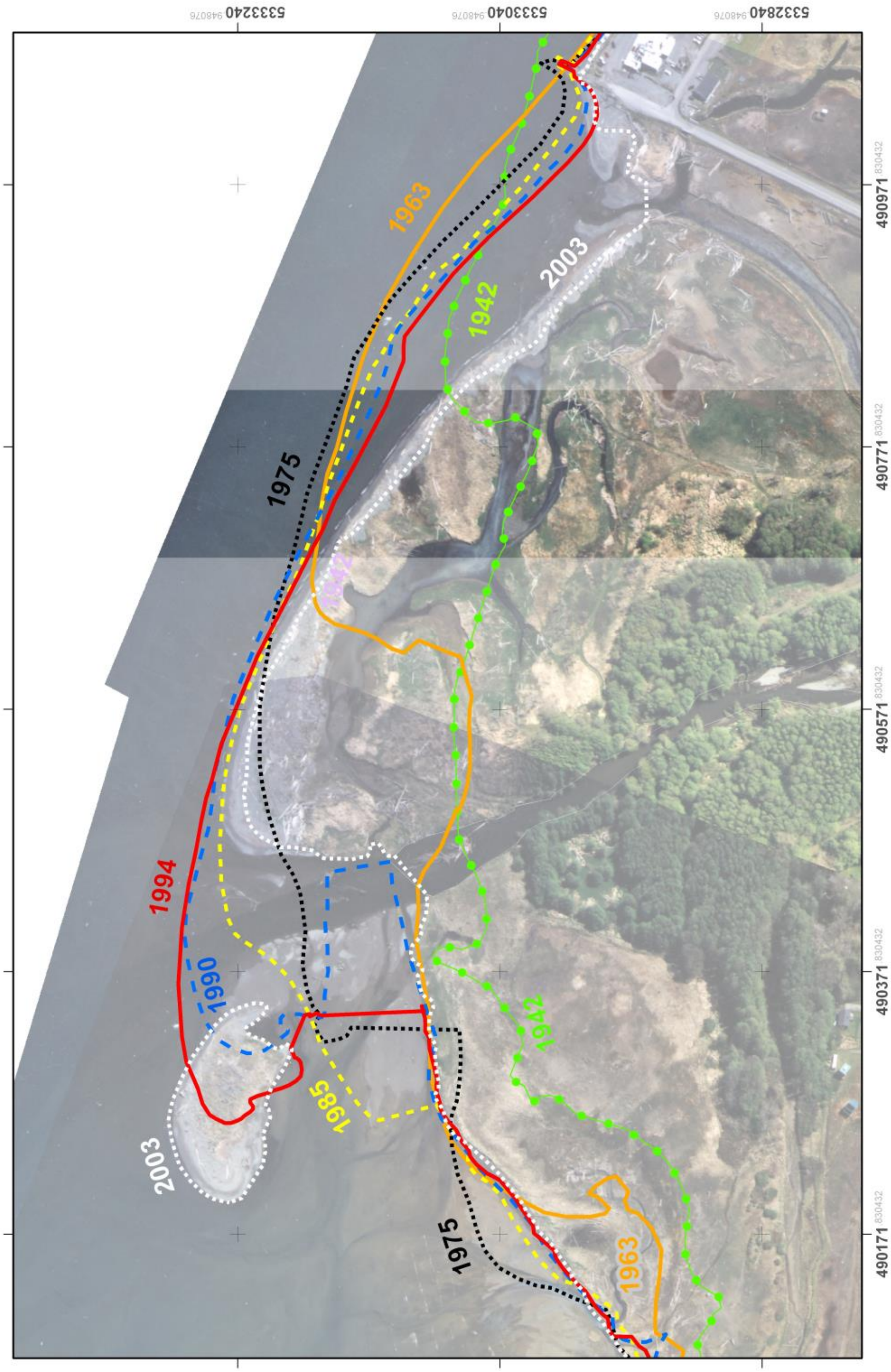


Figure 20. Shoreline locations, as shown in Figure 15, but for 1942-2003 and for the area of the modern Dungeness River delta. Background is 2003 color aerial photographs. Graticule is UTM North and ticks are every 500 m.

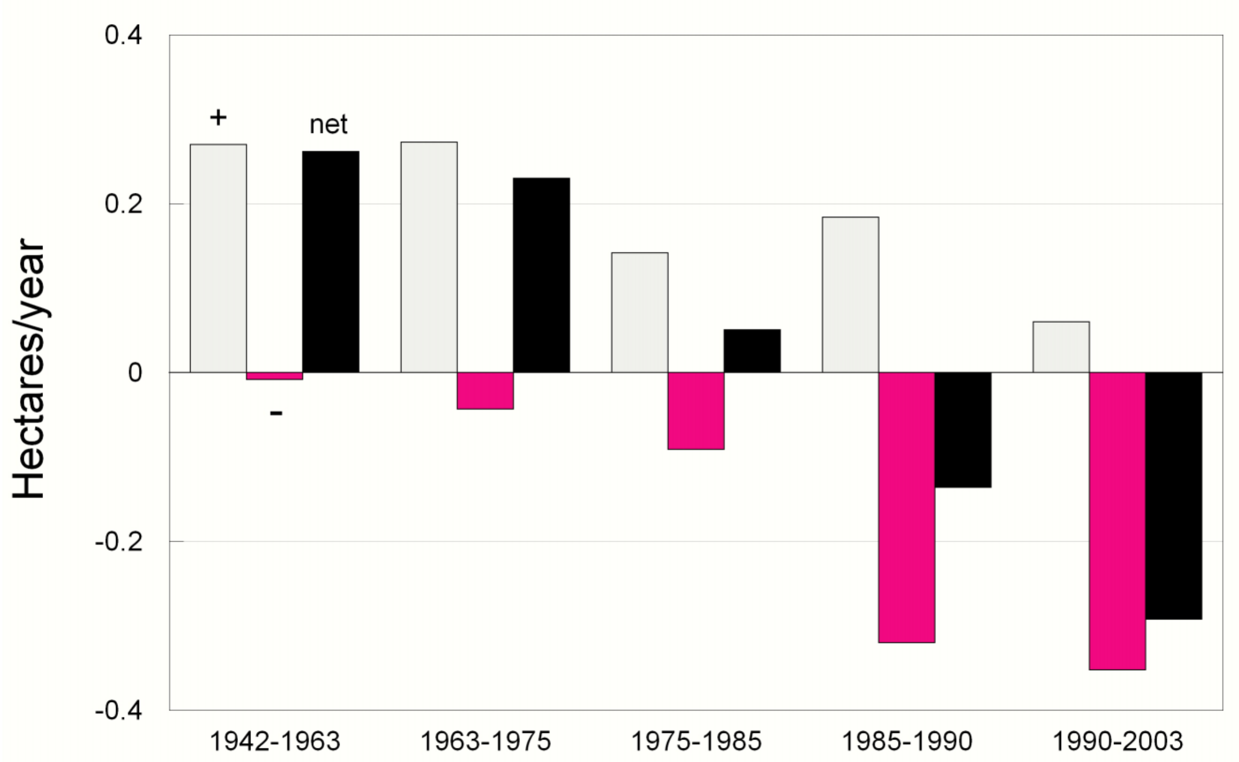


Figure 21. Accretion (gray bar), erosion (red bar) and net change (black bar) of land within area #3 in Figure 19, for five time periods from 1855 to 1903. Change is averaged over each time period and expressed as hectares per year. Data were created using the shorelines shown in Figure 20 and mapped from aerial photographs.

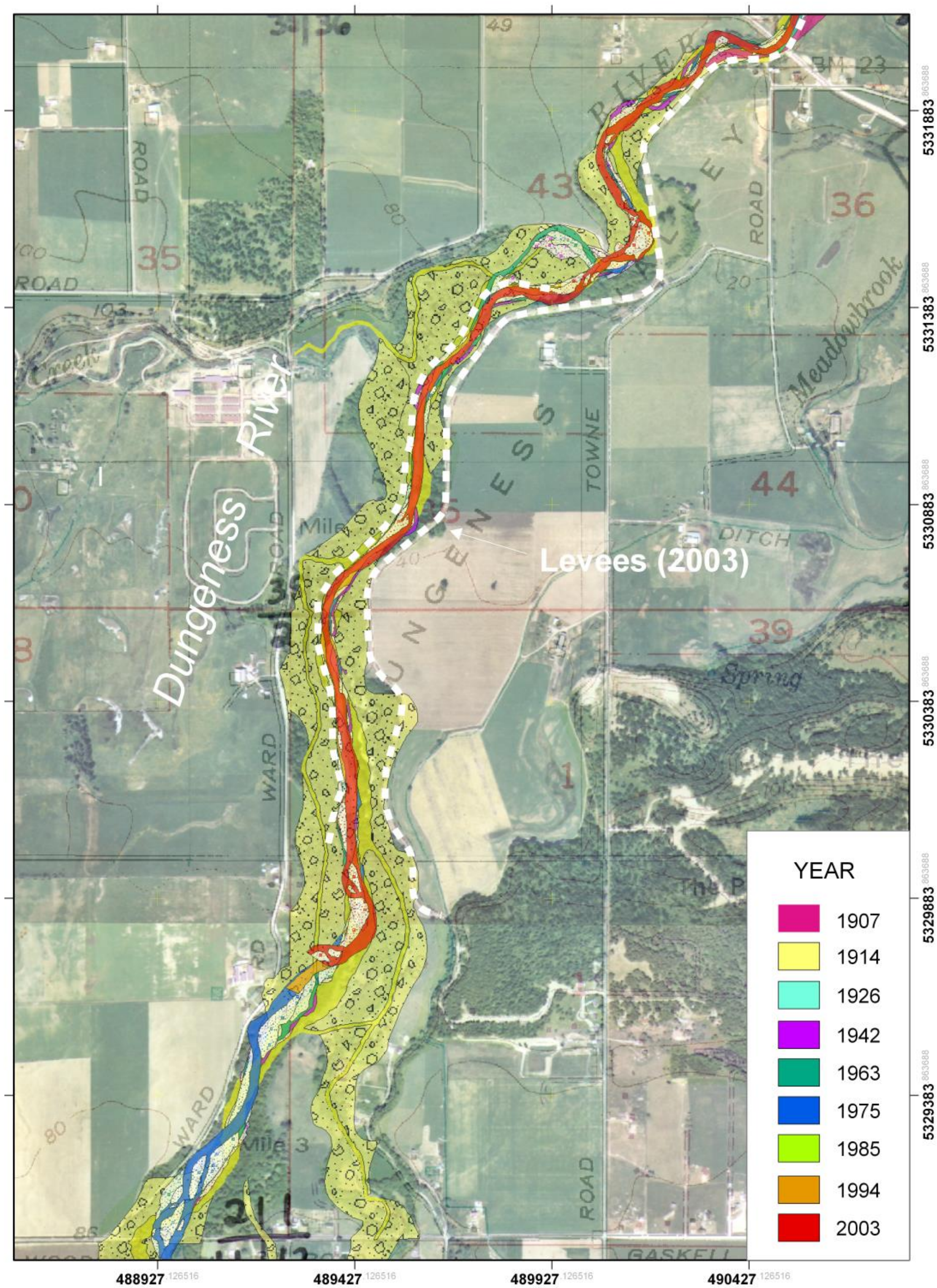
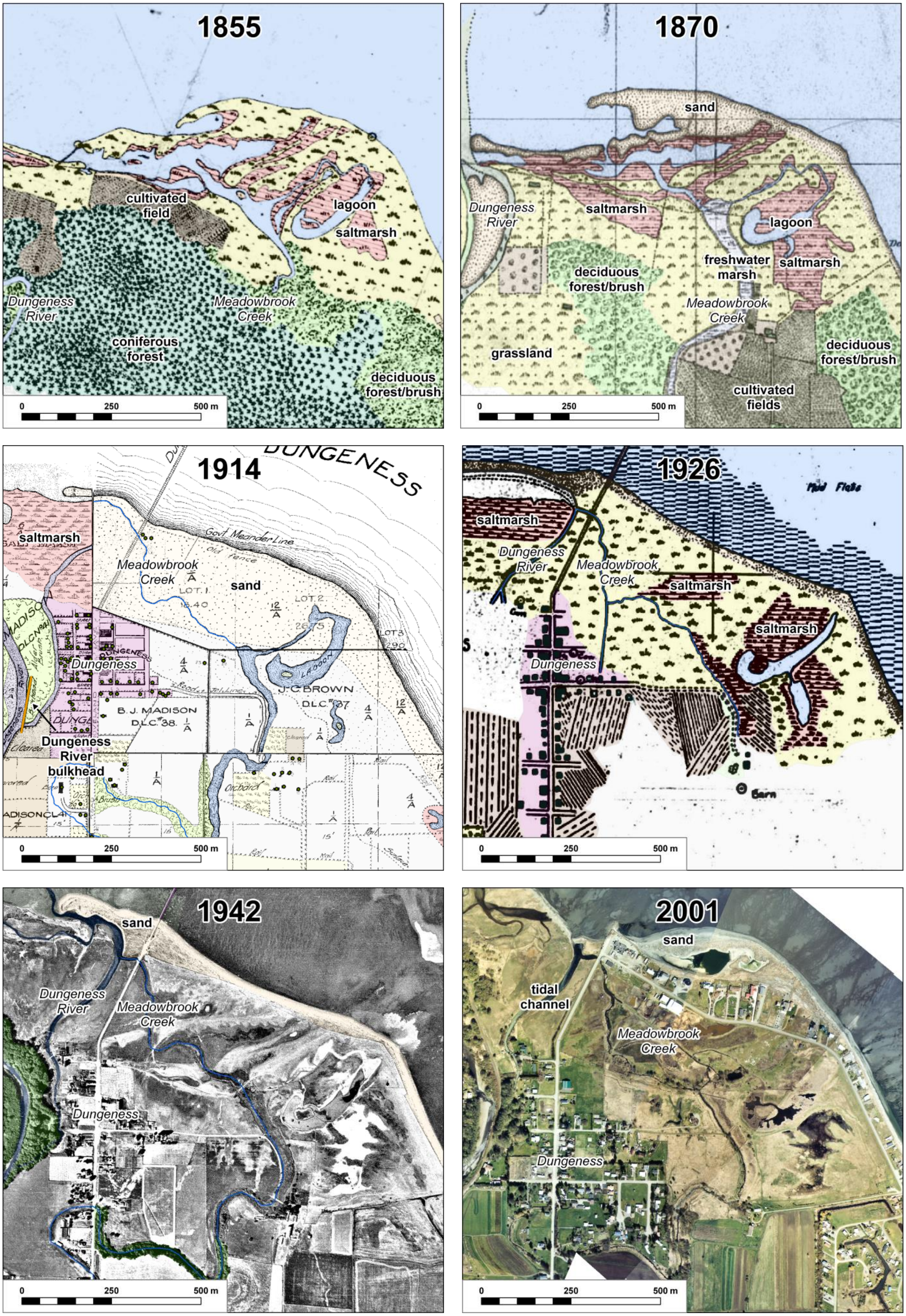


Figure 22. Channel positions of the lower Dungeness River, between Schoolhouse Road and Woodcock Road bridges, RM 0.9 to RM 2.8, from 1914 to 2003.

Figure 23 (following page). Changes to the Meadowbrook Creek estuary, 1855-2001. 1855 from USC&GS T-0539 (scale 1:10,000); 1870 from USC&GS T-1168 (1:10,000 scale); 1914 from Clallam County Assessor maps; 1926 from T-4194 (1:10,000 scale); 1942 from black and white aerial photography (scanned 9” x 9” prints, 1:20,000 scale); 2001 from 1:6,000-scale color aerial photography.



1855
lagoon
saltmarsh
cultivated field
Dungeness River
Meadowbrook Creek
coniferous forest
deciduous forest/brush
0
250
500 m
1870
sand
saltmarsh
Dungeness River
lagoon
freshwater marsh
saltmarsh
deciduous forest/brush
Meadowbrook Creek
grassland
deciduous forest/brush
cultivated fields
0
250
500 m
1914
DUNGENESS
saltmarsh
Meadowbrook Creek
sand
Govt Meander Line
Old Fence
LOT 1
LOT 2
LOT 3
LAGOON
Dungeness
J. C. BROWN
D.L.C. 37
B. J. MADISON
D.L.C. 38.
Dungeness River bulkhead
Orchard
0
250
500 m
1926
Mud Flats
saltmarsh
Dungeness River
Meadowbrook Creek
saltmarsh
saltmarsh
Dungeness
Barn
0
250
500 m
1942
sand
Dungeness River
Meadowbrook Creek
Dungeness
0
250
500 m
2001
sand
tidal channel
Meadowbrook Creek
Dungeness
0
250
500 m

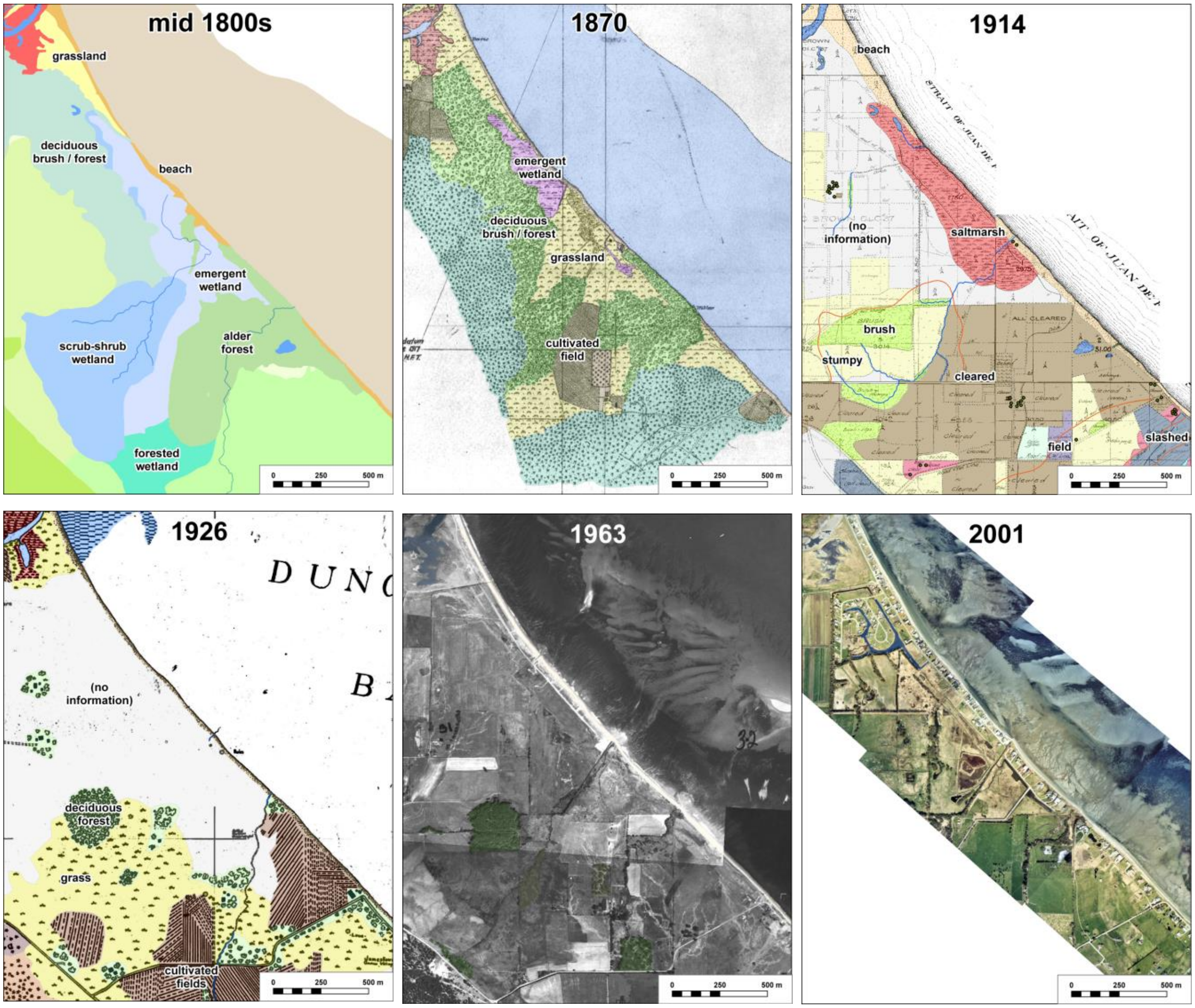


Figure 24. Changes to the coastal plain SE of Meadowbrook Creek delta.

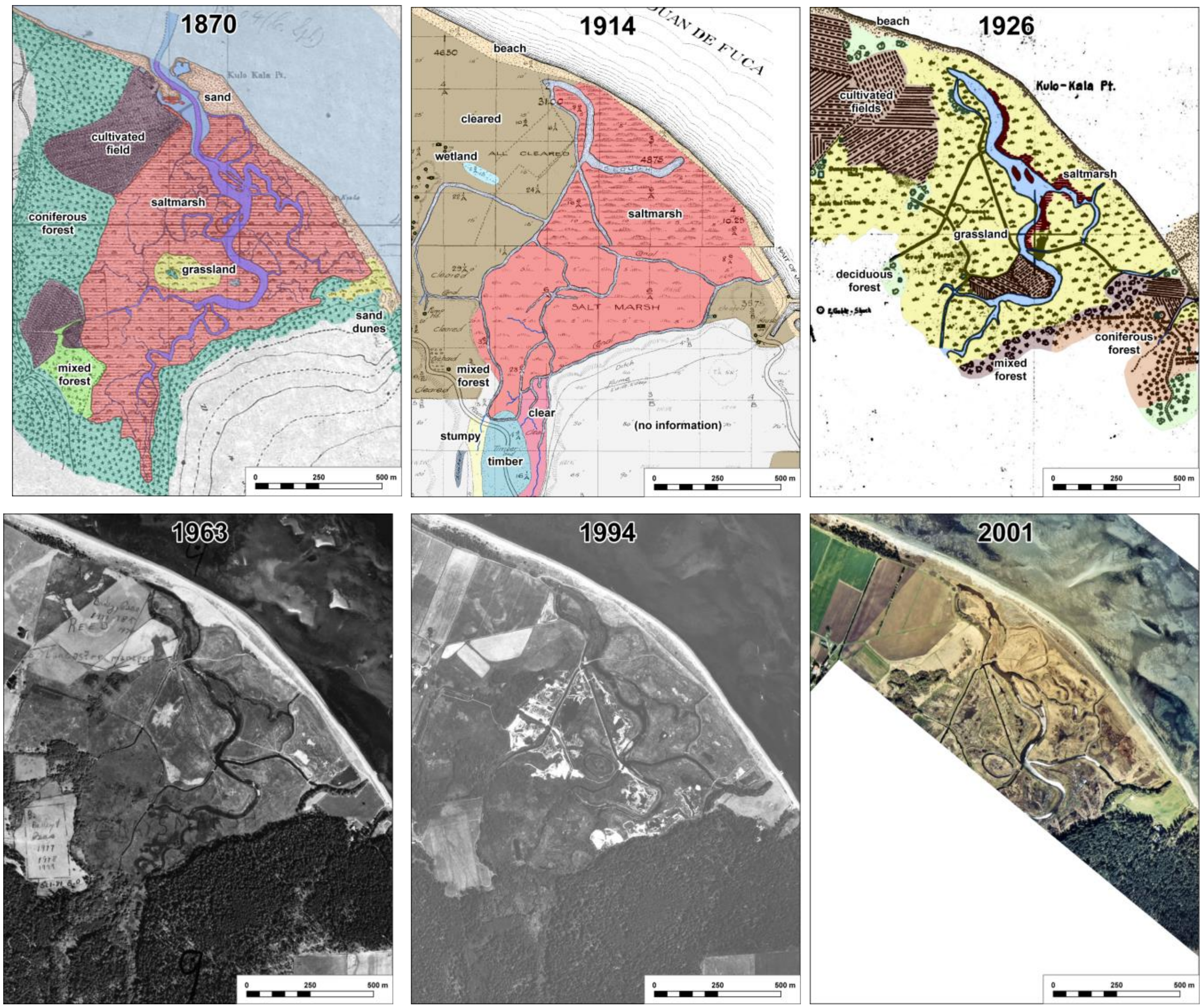


Figure 25. Changes to Graysmarsh, 1870-2001.

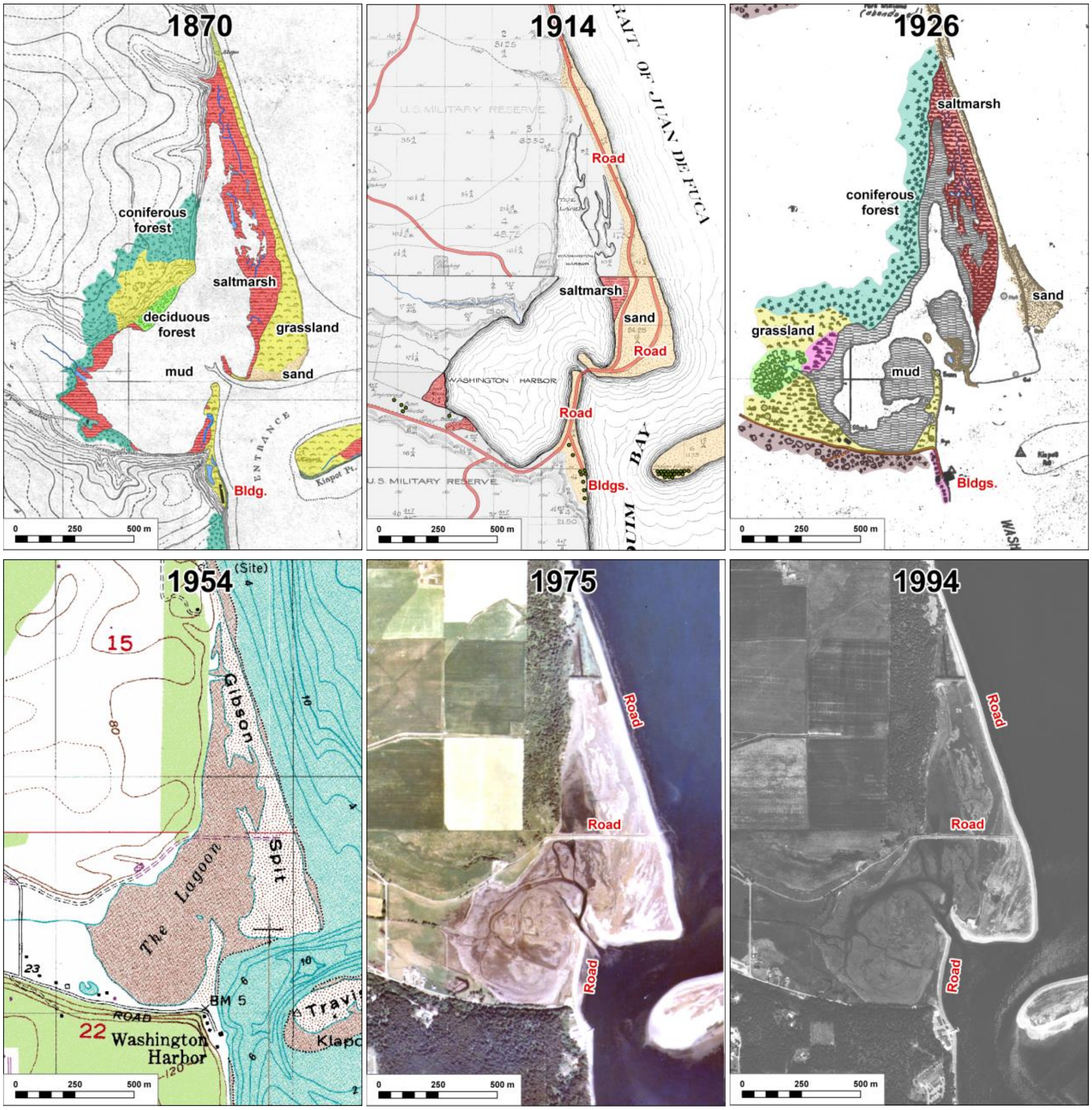


Figure 26. Changes to Washington Harbor, 1870-1994.

Acknowledgments

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Cover photo credit: Clallam men on beach with the Shaker church in the background, Jamestown, Washington, ca.1903 (Barnes, A. H., b. 1876). Clallam men in western-style clothes on beach with white man writing in notebook; in background is a woman standing by crabtraps. In the background right is the Shaker church, ca. 1900-1906. Albert Henry Barnes Collection no. 542. University of Washington Libraries. Special Collections Division.

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APPENDIX 1: DATA AND INFERENCES USED IN CHARACTERIZING HISTORICAL ENVIRONMENTS

This appendix consists of information used to map features in the historical conditions GIS layer, and explanations of the logic and assumptions with which the data were used. Features are organized in six landscape categories. Features are referenced by their "FEATURE_ID" code in the GIS layer. The order in which landscape categories are given, and the subdivisions within each, are: (1) Pleistocene glacial deposits; surfaces on older Holocene alluvium: (2) Prairies; (3) Bell Creek Dungeness River paleochannel and Washington Harbor; (4) Gierin Creek Dungeness River Paleochannel and Graysmarsh; (5) Cassalery Creek Dungeness River Paleochannel and associated alluvial fan; (6) the Dungeness River valley; and (7) the coastal plain.

(1) Features on Pleistocene Glacial Deposits

With the exception of a large prairie south of the original location of the town of Dungeness (DNG_PR3104001), mapped features are small, scattered prairies and wetlands.

Prairie near Old Town DNG_PR3104001 *(123 hectares).* Described in GLO field notes as "prairie." Shown on T-0539 with grassland symbol. On T-0539 (1855), it includes 33 hectares of fields, assumed to have been prairie pre-settlement. Boundaries of the prairie were expanded on the south (landward) edge, using 1859 GLO plat map and line notes, from field mapping in 1858. Heading northward between S. 35 and S. 36, T31NR04W, at 68.30 chains "Leave timber N. W. & S. E. & enter prairie. Abernethys house bears S. 63 30 E" and then at 72.40 chains "Enter field E & W." North between S. 34 and S. 35, same township, at 68.25 chains "Enter prairie N.W. & S.E." and at 72.60 chains "cross fence E & W." Both lines were surveyed on June 3rd 1858.

"Gibson Prairie" DNG_PR3004003 *(32 hectares).* Not described in GLO field notes; shown on plat map, identified by label on road leading to prairie "Road to Gibson Prairie," and label at prairie "Gibson." Includes 8 hectares of field assumed to have been prairie prior to settlement.

“Davidson” Prairie DNG_PR3004004 *(21 hectares).* Not described in GLO field notes because not crossed by survey line, but shown on plat map as immediately adjacent to line between S. 3, T30NR03W and S. 34, T31NR04W. House in prairie labeled “Davidson.” Assumed to have been prairie prior to settlement.

Prairie DNG_PR3104007 (*18 hectares; west of Lotzgesell Road near bluff).* Boundary of prairie is not fully drawn on GLO plat maps. Field notes indicate that part of prairie map unit was a field: westward on north boundary of S. 4, T30NR04W, at 60.2 chains “enter field” and at 79.5 chains “Enter brush & leave prairie.”

Emergent palustrine wetland DNG_W3003009. Wetland is on glacial terrace on bluff near Port Williams. In GLO line notes (1859), between S. 10 and S. 15, T30NR03W, eastward at 17.00 chains “enter grass swamp N. 60 W & S 60 E” and at 31.00 chains “leave same N & S.” Wetland boundaries (except along section line) were modified using T-1169 (1870); wetland was narrowed on basis of mapping of field (assumed to have been marsh) and forest boundary on east, and wetland was elongated to north, based on mapping of grassland (also assumed to have been marsh).

Additional small wetlands in the same area include emergent wetland **DNG_W3004005**, 4.6 hectares, mapped from GLO notes and plat maps (westward on north boundary of S. 3, T30NR04W at 30.75 chains “Enter open grass swamp N & S W”), **DNG_W3004006**, 4.5 hectares, mapped from the GLO notes and map, and boundary refined from aerial photos. North between S. 3 and S. 4, T30NR04W, at 20.40 chains, “Enter grass swale, E & W.” **DNG_W3004007**, 2.7 hectares, mapped from GLO notes and map, and boundary refined from aerial photos: north on line between S. 9 and S. 10, T30NR04W, at 77.80 chains “Swale 150 links courses E. & W.”

(2) Prairies on older Holocene alluvium

"Squim Prairie" (DNG_PR3003006) and associated woodlands and wetlands. The Sequim Prairie was 681 hectares, excluding two woodland areas within the Prairie area; including the woodlands the prairie was 751 hectares. GLO surveyors describe the Sequim Prairie along section lines as "prairie" or "open prairie." The 681hectares includes 109 hectares that the GLO mapped as fields in 1858; these fields are assumed to have been prairie prior to settlement. The two woodland areas, **DNG_PR3003001a**, totaled an additional 70 hectares (49 hectares and 21 hectares). The larger, more central woodland was described in line summaries (between S. 18 and S. 19, T30NR01W) as "scattering fir & oak timber" and (between S. 17 and S. 18, T30NR01W) "scattering fir timber & oak do [timber]." The smaller woodland to the west is described as "fir timber" (between S.18, T30NR01W and S. 13, T30NR04W). Two small (10 hectares total) wetlands within the prairie, **DNG_W30030011**, are shown on 1914 Assessor maps. Both are mapped as "peat and muck" soils, and the larger one is annotated "brush and grass" and was crossed by a network of drainage ditches on the 1914 Clallam County Assessor's map.

Two smaller mapped prairies include 50 hectare **Prairie DNG_PR3004001,** to the east of the Dungeness River, west of Bell Hill and northwest of Happy Valley, described as "small prairie" along line between S25, T30NR04W and S. 30, T30NR03W, and 31-hectare **DNG_PR3004002,** west of Dungeness River near Carlsborg. Between S. 15 and S. 22, T30NR04W, referred to in GLO notes as "prairie."

(3) Channels and Wetlands on the Bell Creek Paleochannel and in the Bell Creek estuary

Bell Creek. The GLO plat maps show a channel from the upland emptying into the wetland (DNG_W3003004; see below) to the south of the structure labeled "Jno Bell." The plat maps do not show a continuation of this creek beyond the wetland. The line notes between S. 20 and S. 21, and between S. 21 and S. 22, T30NR03W (1859), which the modern Bell Creek cross, include no notations of channels. T-1169 (1870) shows two small creeks that terminate near the shoreline; it seems likely the creeks drain from the cedar swamp (DNG_W3003003; see below) to the west of the Bell Creek estuary into the lagoon. Topographic traces of older meandering channels appear on the lidar; these may or may not be part of an historical Bell Creek. Lacking evidence for a continuous Bell Creek extending from the base of Bell Hill (DNG_W3003004), only these discontinuous channels apparent on lidar have been drawn.

Palustrine wetland DNG_W3003004. The GLO map shows Bell Creek terminating in this small (7 hectare) wetland at the base of upland. Plat map symbolizes area as wetland, but described as "bottom" in field notes. North between S. 19 and S. 20, T30NR03W, at 2.50 chains, "Enter bottom E & W;" at 12.00 chains, "Enter scattering fir & oak timber E & W." West between S. 19 and S. 30, T30NR03W, at 2.5 chains "Enter maple bottom N.E. & S.W.;" at 13.00 chains, "Leave same & enter timber N & S." GLO plat map shows Bell Creek terminating in the wetland.

Palustrine wetland DNG_W3003003 *(wetlands in the Bell Creek Paleochannel, totaling 68 hectares).* Primarily a forested wetland ("cedar swamp"); a portion was emergent marsh (DNG_W3003003a). East between S. 16 and S. 21, T30NR03W, at 11.00 chains "Enter cedar swamp N & S;" at 17.5 chains, "Enter open grass swamp N & S;" at 36.5 chains "Leave swamp & enter timber N.W. & S.E." North between S. 21 and S. 22, T30NR03W, at 58.00 chains "Enter swamp E & W;" at 72.0 chains "Leave swamp E & W." **DNG_W3003003a** mapped on basis of GLO description ("open grass swamp"), which coincides with drained and cultivated portion of wetland W3003003 as shown on 1914 Assessor map.
DNG_W3003003b is a continuation of DNG_W3003003a, not crossed by GLO section line, but shown on Assessor map in same way as DNG_W3003003a. **DNG_W3003003c** is an extension of DNG_W3003003 within the interior of S. 21, T30NR03W having "peat and muck" soils on Assessor map. DNG_W3003003d is an extension of DNG_W3003003 at the down-valley end of the wetland, up-valley from and adjacent to the Bell Creek estuary saltmarsh (DNG_W3003006); this area is not crossed by the GLO survey, and not mapped on T-1169, is surmised to be wetland and the map unit has a low certainty rating. The lower part of DNG_W3003003 and **DNG_W3003003d** is limited on the south side

by a low terrace (~1.5 m high), higher ground on which early settlement and the road to Sequim Prairie were located.

Estuarine wetland DNG_W3003006 *(Bell Creek estuary saltmarsh).* Large intertidal lagoon was 42 hectares (all measurements are from T-1169, 1870). Gibson Spit, the main barrier spit attached to the mainland on the north end of the lagoon, included 12.8 hectares of saltmarsh (including 0.2 hectares of channels shown on T-1169), 8.2 hectares symbolized by sparse grass (interpreted as grass on sand), and 1.2 hectares symbolized as sand. The mainland shoreline included 2.7 hectares of saltmarsh. The smaller spit attached at the lagoon's southern end included 0.8 hectares of saltmarsh (including channel area), and 0.9 hectares of sparse-grass symbol (interpreted as sparse grass on sand). This spit continued southward past the prominent point of land (to the modern hamlet of Washington Harbor) as 0.9 hectares of sparse-grass symbol and 0.2 hectare lagoon.

(4) Channels and Wetlands on Gierin Creek Paleochannel and Graysmarsh

Gierin Creek. The location of Gierin Creek, as shown in the GIS coverage, draws from the 1914 Clallam County Assessor maps, lidar, and 1942 and 1963 aerial photographs. Upstream of the channel as shown, Gierin Creek had already been ditched by 1914, and relict channels on early aerial photographs are faint and ambiguous; consequently the upstream part of Gierin Creek is not mapped in the GIS coverage.

Palustrine wetland DNG_W3003002 *(Gieren Creek wetlands; 59 hectares).* A "cedar swamp." North between S. 16 and S. 17, T30NR2W, at 51 chains "foot of descent & enter Cedar swamp NE & SW;" at 62.5 chains "Enter burnt timber & leave swamp E & W;" at 75.5 chains "Enter cedar swamp & W." Line summary includes "North 39 chains mostly cedar swamp." **DNG_W3003002a** is a downvalley extension of DNG_W3003002 into the interior of S. 9; area is mapped as peat in 1909 soils mapping. Lidar was used to restrict the lateral extent of wetland map unit between terraces 2-3 m above floodplain. The map unit is continuous downvalley with Graysmarsh.

"Graysmarsh" estuarine wetland DNG_W3003007. Mapped as estuarine emergent marsh. It is described in GLO line notes (1859) between S. 4 and S. 9, T30NR03W as "open tide marsh" and symbolized on T-1169 (1870) as saltmarsh with no tree symbols; soil is described as "saltmarsh" on 1914 Clallam County Assessor maps. Tidal channels are as shown on T-1169. Includes a small (3 hectares) inclusion (**DNG_W3003007a**) symbolized on T-1169 as grassland, with a very small (0.01 hectare) patch of forest in its center.

Forested palustrine wetland DNG_W3003008 *("Cedar swamp" west of Graysmarsh).* Mapped by GLO adjacent to Graysmarsh to the west. Line notes indicate: eastward between S. 4 and S. 9, T30NR03W, at 4.00 chains "foot of descent & enter cedar swamp N. W. & S. E." then at 19.5 chains "enter open tide marsh [Graysmarsh]." **DNG_W3003008a** is a continuation of the wetland, adjacent to DNG_W3003008 extending into the interior of S. 4, T30NR03W, beyond the extent shown on the GLO map. Both areas are mapped in 1909 US Bureau of Soils map as peat soil, but map boundaries are very approximate, having a scale of 1:125,000. A portion of DNG_W3003008a could instead be an extension of Graysmarsh (saltmarsh); soils of that part are mapped as saltmarsh on the 1914 Assessor map; T-1169 maps this portion as a field, which could correspond to easily-cultivated (not requiring forest clearing) saltmarsh. On the other hand, the surface of DNG_W3003008a is roughly 1 m higher than the adjacent Graysmarsh; but this could reflect differential settlement since the settlement era, because Graysmarsh has been mostly ditched and drained. DNG_W3003008a is mapped as palustrine wetland, keeping in mind that alternatively it could have been saltmarsh. Both DNG_W3003008 and DNG_W3003008a are lower in elevation than the surface to the west, which is that of the alluvial fan associated with the Cassalery Creek Paleochannel.

(5) Features on Cassalery Creek Paleochannel and associated alluvial fan

Cassalery Creek. The location of Cassalery Creek has been estimated from the GLO plat maps, topography on lidar, and 1963 aerial photos. Cassalery Creek flows within a surface, clearly identifiable on lidar imagery, from 20 to 200 m wide, inset roughly 1.5 m below the surface of the Cassalery Creek Paleochannel.

Palustrine wetland DNG_W3003005. Small (9 hectare) wetland SE of Towne Road and Gaskell Road intersection, and NW of Cassalery Creek, on northwest (left bank) side of Cassalery Creek Paleochannel. Shown as wetland on GLO plat map, described in GLO field notes as "alder & grass swale" (northward between S. 7, T30NR03W and S. 12, T30NR04W, between 51.5 chains and 62.5 chains) on May 5, 1858. Boundaries are as shown on plat map, lacking other information to refine boundary.

The Cassalery Creek Paleochannel grades into a large alluvial fan, described in the text. An alder forest is mapped at the lower north and northwest fringes of the fan; the alder forest is adjacent to a wetland complex on the coastal plain between the nearly coalescing fans from the Cassalery Creek Paleochannel and from the modern Dungeness River valley. The latter wetland extends southeast into an incised portion of the Cassalery Creek fan. This wetland-alder forest complex on the fan and adjacent to it on the coastal plain are described as part of the coastal plain, below.

(6) Features in the Dungeness River valley

Dungeness River. The Dungeness River as shown does not represent the location or condition of the river in pre-settlement time. The GLO plat maps show only a sketched version of the river, which was not meandered (see text). The GIS coverage instead shows a depiction of the river from the 1914 County Assessor maps. The rationale for using data from 1914—well after the early settlement period—is that it is the earliest relatively detailed map available. The location of **Matriotti Creek** has varying degrees of certainty. It was drawn from lidar, 1942 and 1963 photographs, 1914 Assessor maps, and the GLO in different segments of the creek.

(7) Wetlands and Channels on the Coastal Plain

Palustrine wetland DNG_W3003012 *(wetland northwest of Jamestown and near mouth of Cassalery Creek).* This wetland complex was on the lower part of the large alluvial fan from the Cassalery Creek Paleochannel, and in the Coastal Plain between that fan and the large fan from the modern Dungeness valley. Much of the area is mapped as peat soil on the 1914 Clallam County Assessor map and on geologic maps. **DNG_W3003012** is mapped as emergent wetland. It is located in a low-elevation trough between the two Holocene fans mentioned above, and is shown on GLO plat maps. The GLO survey crossed the feature along two section lines on May 5th, 1858: heading northward between S. 31 and S. 32, T31NR03W, at 16 chains, "leave thick alder & enter open marsh N. E. & S. W.," then at 35 chains "enter thick alder timber N. W. & S. E." Heading eastward between S. 31, T31NR03W, and S. 6, T30NR03W, at 64 chains "Enter grass marsh N. E. & S. W.," then at 69 chains "Enter alder timber, N. & S." The mapped area also generally corresponds to areas symbolized as field and grassland on T-1168 (1870). GLO plat maps show **DNG_W3003012a** as wetland. Surveyors crossed the feature twice along the line between S. 6 and S. 5, T31NR03W. Heading northward, at 34.0 chains "enter alder bottom," at 41.0 chains "leave alder bottom," and at 58.0 chains "enter alder bottom." The northern margin of the feature is not recorded in the notes, but the plat map shows the wetland ending at about 64 chains. We map DNG_W3003012a forested wetland. North and northeast of DNG_W3003012a we map a large area as alder forest. The extent of the alder forest is based on the GLO descriptions "thick alder" between S. 31 and S. 32, and "alder timber" between S. 31 and S. 6. We also used the extent of deciduous forest symbol on T-1168 to delineate the map unit; this unit is not mapped as wetland, but is mentioned in this description because it is related to the complex. One interpretation is that DNG W3003012a was a particularly wet area of the alder forest owing to its topographic position, but the entire area shares a similar geomorphic position at the lower portion of the alluvial fan associated with the Cassalery Creek Paleochannel. **DNG_W3003012b** is mapped to the west of DNG_W3003012, roughly coincident with the limit of "peat and muck" soils in the 1914 Clallam Assessor maps, and roughly coincident with (faintly drawn) wetland symbol on the GLO plat map. The wetland is not mentioned in the GLO notes, between S. 31 and S. 6. Several creeks originate within the map unit. We lack information on the vegetation. The line notes (notes for the entire line, including parts that do not pass through DNG_W3003012b) indicate "Land low & mostly swampy. Timber fir, Cedar, alder & some Spruce. Undergrowth brier, arrowwood, salllal, gooseberry & c." Bearing trees on the western edge of the map unit are spruce and cedar. The 1914 Assessor maps show a portion of the area that could be original vegetation (lacking stumps, unlike surrounding areas) as "brush." We have mapped the unit as scrub-shrub wetland, possibly characterized by scattered cedar and spruce trees.

Unnamed stream between Cassalery Creek and Meadowbrook Creek. The stream drains the large wetland complex DNG_W3003012. Its location is based on 1942 and 1963 aerial photographs, and, near the mouth, T-1168.

Palustrine wetland DNG_W3103001 *(wetland on coastal plain between Cassalery Creek wetland complex and Meadowbrook Creek wetland complex).* T-1168 (1870) shows DNG_W3103001 as wetland. T-0539 shows a portion of the area as wetland; on the whole, the earlier (1855) T-0539 is less reliable than T-1168 (187), based on a comparison of the two with other sources. DNG_W3103001 is also within an area shown as wetland on the 1914 Clallam County Assessor maps. The GLO survey does not cross this map unit. We map DNG_W3103001 as PEM. T-1168 shows **DNG_W3103001a** on the inland fringe of DNG_W3103001 as wetland with patches of trees; it is also within the area mapped as wetland by the 1914 Assessor maps. We map DNG_W3103001a as PSS. **DNG_W3103001b** is a continuation of DNG_W3103001, to the southeast. The 1914 Assessor map shows it as wetland. T-1168 maps it as grassland; dikes appear to separate it from DNG_W3103001. The GLO survey crosses a portion of DNG_W3103001b, describing it as "open marsh." A NW-SE running, linear band of "thick alder timber" (GLO) nearly splits the map unit; this band of trees is shown on T-1168 as well as described in the GLO notes; we have mapped it using the same alder forest unit used adjacent to DNG_W3003012. We map DNG_W3103001b as a continuation of DNG_W3103001, as PEM. The wetland continues to the southeast (**DNG_W3103001c)**, and adjoins DNG_W3003012. It is outside the bounds of the wetland shown on the 1914 Assessor map, but is crossed by the GLO line describing it as "open marsh." We have delineated the unit's margins to the southeast using the boundary between grassland and deciduous forest or brush on T-1168; to the south, DNG_W3103001c is continuous with DNG_W3003012.

Meadowbrook Creek. Meadowbrook Creek is mapped from the GLO maps and field notes, and from 1942 and 1963 aerial photos. The river's mouth is drawn from T-0539.

Estuarine emergent wetland DNG_W3103002 *(Saltmarsh associated with Meadowbrook Creek delta).* Mapped from T-0539 because T-0539 is the earliest source, and because features mapped near to shore on T-0539 are presumed to be accurate (unlike inland, where features appear sketched, in comparison to the later T-1168, where inland features appear to have been mapped). Wetlands are protected by a sand berm (shown as grassland on T-0537, but distinguished from grassland immediately shoreward on T-1168). Wetland exists in patches, either fringing the barrier sand spit, or intermixed with area mapped "grassland" on both T-1168 and T-0539 and several lagoons, including one large lagoon which is consistent in shape with its being an abandoned channel of the Dungeness River. Grassland area could be grass-covered sand, by analogy to the 20th century condition and history of the modern Dungeness delta (see main report). Inland and extending along the coastal plain to the southeast we map "brush." This is based in part on the description "brush/deciduous forest" along three section lines crossing the map unit (between S. 30 and S. 31, T31N R03W, between S. 25 and S. 30, T31N R03W, and between S. 25, T31N R03W, and S. 36, T30 N R03W). It is also based on symbology showing dense deciduous forest on T-1168 and T-0539.

Estuarine emergent wetland DNG_W3104001 *(Dungeness Spit saltmarsh)* and **Estuarine emergent wetland DNG_W3104002** *(Cline Spit saltmarsh)* are mapped as shown on T-0539. **Estuarine emergent wetland DNG_W3104003**, saltmarsh associated with the 1870-onward Dungeness River mouth, and **DNG_W3104005**, saltmarsh associated with the 1855 Dungeness River mouth, are both mapped as shown on T-0539. **Palustrine emergent wetland DNG_W3104004,** associated with the 1870-onward area of the Dungeness River delta, is mapped as grassland on T-0539, but as “low marsh” in GLO field notes (see caption for Figure 2).