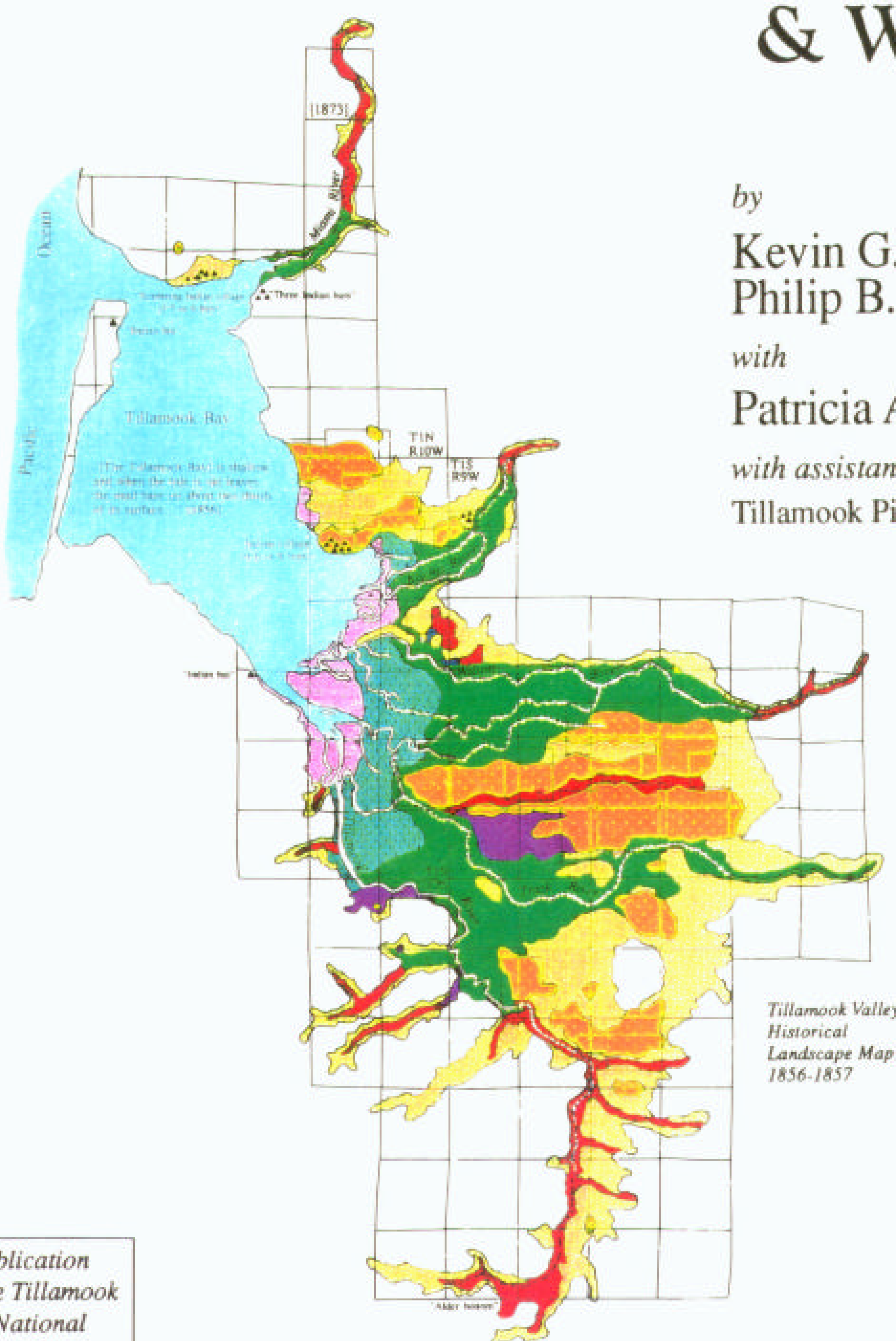
An Environmental History of the Tillamook Bay Estuary & Watershed



Tillamook Valley Historical Landscape Map 1856-1857

by

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with assistance from the

Tillamook Pioneer Museum

A publication of the Tillamook Bay National Estuary Project

AN ENVIRONMENTAL HISTORY OF THE TILLAMOOK BAY ESTUARY AND WATERSHED

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TABLE OF CONTENTS

Page No.

List of Figures

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LIST OF TABLES

LIST OF PLATES

Executive Summary

This study provides a history of environmental changes in Tillamook Bay and its watershed. Its purpose is to develop a better understanding of historic changes in the ecosystems and the regional landscape since the time of the Euro-American settlement. These changes were assessed by focusing on key indicators of environmental change — including sedimentation, water quality and estuarine, wetland and riverine habitat. As part of the Comprehensive Conservation and Management Plan (CCMP), these historic findings and summaries of resource change can provide insight for future resource management in the estuary).

There is a wealth of existing historic data on the Tillamook area. PWA reviewed much of this information and used it to develop a narrative historical account of the Bay and watershed environment. Starting with diaries and ship logs of the early explorers to the Oregon coast at Tillamook in the 1700's which were pieced together to form an understanding of the landscape and ecosystem conditions as seen through the eyes of these adventurers.

In this study, a significant effort was made to supplement existing historic information by compiling additional historic spatial and statistical summaries for this region. New spatial data was prepared by reconstructing the historic 1850's landscape through surveyor field notes from the General Land Office township, donation land claim original field survey notes and foresters' observations of the region as documented in the 1908 Timber Cruise of Tillamook County. A Geographic Information System (GIS) was also employed to develop new spatial data. Using mapping from the first bathymetric survey of the Bay in 1867 and the first quadrangle mapping of the region from the 1930's, this GIS shows historic changes in the Tillamook Bay shoreline and planform changes of the major rivers in the lower valleys. New statistical summaries on agricultural commodities and land use trends have been compiled by researching the First U.S. Census of Agriculture in 1840 to the 24th Census in 1992.

The third section of this report is a narrative that weaves an historic environmental story for the reader. It begins with a discussion of the geomorphic history of the region by describing the natural forces which have shaped the landscape for millennia. The narrative continues with historic accounts of how both natural forces and human interventions as well as the human use of natural resources have changed the regional landscape. This history is discusses major time periods, including the period of the Native American landscape (before 1800), the era of settlement (1800 to 1900), and the managed landscape (1900 to the present). The narrative concludes with discussion of the environmental impacts of and responses to human settlement of the landscape.

The fourth and fifth sections of this report contain the results of historical research critical to the needs of the National Estuary Project and is therefore more detailed than the narrative. These sections include a history of the ecological functions and importance of large woody debris in the Tillamook Estuary ecosystem (Section IV) and historic reconstruction mapping of the lower river valleys of Tillamook Bay (Section V). These historic data have been compiled to provide a basis for future resource management decisions concerning baseline ecosystems conditions for environmental restoration projects.

Conclusions from the historic research are itemized in the second section of the report and are grouped in a manner corresponding to geographical elements of the Tillamook Bay ecosystem. The conclusions are derived from key observations from the historic research: they relate to the character of the ecosystems prior to settlement, the nature of ecosystem changes over time, and the contribution and effect of human interventions.

Significant conclusions about the Tillamook region ecosystem conditions can be made from historical records dating back to the 1700's. The accounts of early European explorers, such as

John Meares in 1778, indicate the coast near Tillamook consisted of “spacious lawns and hanging woods” and “an open champaign country.” These descriptions lead to the conclusion that the early landscape was a mixture of forest and prairie which may have been controlled to some extent by burning by the Native Americans.——As European contact increased, a disease epidemic swept through the Native American population of the Pacific Northwest. The decimation of the Native American population may have reduced the frequency and extent of burnings, and thus possibly, allowed the extension or re-establishment of forests on the lowland floodplains through the mid 1800's (Botkin, 1995).

EuroAmericans settled Tillamook in 1851 and as human populations grew, human interventions into the natural functioning of the landscape increased. Natural wood jams, which tended to increase the frequency and duration of overbank flooding — creating hydraulic connections between the riverine, estuarine and terrestrial systems — were removed for the sake of navigation. Levees and dikes were constructed to protect the increasing value of valley farmlands from the natural cycles of flooding. These interventions separated the rivers from their floodplains and simplified the natural structural complexity of these systems — systems which had sustained a rich fishery for years. Other interventions, such as the construction of jetties at the entrance channel of the Bay, have provided stability to improve navigation, but have also altered the natural processes of the Bay and changed tidal and salinity patterns to various degrees. These kinds of artificial interventions rely on indefinite maintenance and repair. If left to deteriorate the natural processes gradually reassert themselves, restoring floodplains or the natural entrance to the Bay.

The major forest fires of the early to mid twentieth century — for which the Tillamook area is still known — represented a significant impact to the Tillamook Bay ecosystem and caused an accelerated rate of upland erosion and a corresponding increased sediment load to the Bay (Tillamook Bay Task Force, 1978). However, these events have been relatively brief interruptions to the natural degradation and sedimentation of this coastal landform occurring over geologic time. The massive reforestation efforts following the fires have succeeded in restoring forest vegetation and returning watershed erosion to more natural conditions. The most significant sediment sources today involve mass wasting from the natural phenomena of landslides and the human-induced problems of mountain road and culvert wash outs.

I. Introduction

The Tillamook Bay Estuary has been included in the EPA's National Estuary Program both because of the importance of its resources for the State of Oregon, and because it is representative of estuaries within the Coast Range ecoregion of the Pacific Northwest. The development of an effective Comprehensive Conservation and Management Plan (CCMP) for Tillamook Bay is intended to protect and restore key valued resources. Its implementation will therefore not only have beneficial effects locally and regionally, but can also be used as a model for guiding protection and restoration in other estuaries of the ecoregion.

Three primary resource management goals have been identified for the Tillamook Bay National Estuary Project (TBNEP):

1. To achieve water quality standards in order to protect beneficial uses of the Bay, particularly for shellfish;

2. To restore and enhance the Bay from impacts of sedimentation to improve habitat and navigation; and

3. To identify methods and opportunities to protect and enhance anadromous fish spawning and rearing habitats.

As an initial step in addressing these goals the TBNEP has commissioned the preparation of an historic analysis intended to characterize, and where possible to quantify, the trends in resource values within the estuary. This historic analysis can be used to assist in the preparation of the CCMP in five ways:

1. To develop an understanding of the dynamic functioning of the estuarine geomorphic and ecologic systems under pre-Euro-American settlement conditions, that can then be used to guide the formulation of ecosystem restoration and protection strategies;

2. To develop an understanding of the state of the estuarine ecosystem immediately prior to EuroAmerican settlement for establishing a benchmark useful in setting feasible restoration project goals;

3. To identify past trends in key resources to provide indicators of the health of components of the ecosystem, thereby guiding prioritization of restoration actions;

4. To correlate the effect of specific human interventions and of natural events, such as floods, fires, and earthquakes, on key resources to guide in the formulation of restoration actions; and

5. To assist in public education concerning management issues for the Estuary.

Philip Williams & Associates, Ltd. (PWA) was retained by the TBNEP to carry out this historic analysis with the work performed in three phases. Phase I, completed in April 1995, provided an initial assessment of available historic data as it relates to key resource management indicators. Phase II provided an environmental history of the Estuary. Phase III consisted of additional and more detailed analyses of specific indicators required in the further development of the CCMP. This report presents results of these three phases.

Section III of this report provides an overview of the environmental history of the watershed. Sections IV and V, prepared by Patricia Benner, describe in more detail the history of coarse woody debris and the historic landscape mapping carried out in Phase III of the studies.

The study was performed with consideration for other ongoing work being done to characterize the Tillamook Bay watershed. The procedures for conducting an historical analysis were further refined with reference to published scientific papers on the subject.

The study is intended to support objectives of the Tillamook Bay Watershed Analysis Framework. The TBNEP issue forum summaries on sedimentation, water quality and habitat were used as guides for determining the direction for some aspects of the historic analysis.

Research during this historic analysis involved discussions with Bureau of Land Management (BLM), Oregon Department of Fish and Wildlife (ODFW) and Oregon Department of Forestry (ODF) agency staff involved in concurrent project work in the Estuary, so as not to duplicate work efforts and to develop historic data to complement these agency activities. Tillamook County Creamery Association staff, city and county personnel, and local residents were also interviewed to obtain historical information.

II. Conclusions

Estuary/Coastal Zone

- Since the end of the last ice age, the physical form of Tillamook Bay and its adjacent lowlands has developed and persisted over the last 12,000 years. The form of the estuary is a result of a dynamic equilibrium between the effects of sea-level rise, sedimentation, and scour by wave action. This dynamic equilibrium has been punctuated by sudden episodes of tectonic subsidence and by major floods (Glenn, 1978). [Section III. A.]

- The result of this dynamic equilibrium has been to create the physical landscape of floodplains, river channels, marshes, mud flats, and tidal channels that support a highly productive and diverse ecosystem. [Sections III. A., IV.A, IV.B., V.B.]

- Investigations of buried marshes along the Oregon coast indicate major earthquakes have occurred at intervals of between 300 to 1,000 years; the last earthquake occurring about 300 years ago (Komar, 1992). Earthquakes have historically provided abrupt changes to the equilibrium conditions of coastal estuary ecosystems. [Section III.A.]

- Since the first hydrographic survey in 1867, the tidally influenced surface area of the Bay has been reduced by about 11 percent due to sedimentation and artificial fill (Levesque, 1980). [Section III.E.]

- Only three comprehensive hydrographic surveys of Tillamook Bay have been done: in 1866-67, 1957, and, most recently, in 1995. Several studies have been done to quantify sedimentation trends in the bay using the 1866-67 survey as a baseline to compare to other surveys published in 1915, 1943, 1977 and 1984 (Levesque, 1980; the Research Group, 1992). The accuracy of these studies is questionable because: 1) they are limited to comparing subtidal bathymetry below a Mean Lower Low Water datum, which does not include significant portions of the intertidal volume of the Bay; and 2) with the exception of the 1957 and 1995 survey, other surveys used for comparisons to the 1866-67 survey are actually hybrids of that survey, with updated bathymetry limited to portions of the navigable subtidal channels. An analysis of bathymetric and topographic data together — to define intertidal volumes — and a better definition of volumetric error — to define measurement uncertainty — is necessary to better describe morphometric changes in the estuary and estimate sedimentation trends. This work is planned to be accomplished by the TBNEP with the benefit of the 1995 hydrography (Sections III. D., IV. B, IV. C.)

- Construction of the jettied entrance to the Bay in the period 1914 to 1917 and the lengthening of the north jetty in 1932-33 interrupted sand replenishment of Bayocean Peninsula, thus contributing to the erosion and breaching of the spit in 1952 . The breach was artificially closed in 1956. However, during the four years it was open, substantial shoaling occurred in the western portion of the estuary from ocean sediments. Likewise, occasional swells set up by ocean waves entering the breach eroded the southern Bay shoreline (Terich and Komar, 1974). [Section III.E.]

- Between about 1920 and 1975, the number of dairy cows in Tillamook County remained fairly stable at about 15,000. In the last 20 years, there has been a significant increase of about 70 percent to 25,000 cows (U.S. Census of Agriculture, 1860 to 1992 and Brown, 1995). This increase of cows in the valley lowlands increases the potential for waste loading into the estuary. [Section III.D.]

- Since its settlement in 1851, the human population of Tillamook County has grow at an annual rate of approximately 200 residents per year. This increased number of residents, and the associated seasonal influx of tourists, increases the occurrences of marginally treated sewerage and the potential for non-treated discharges to the Bay. [Section III.C.]

- Since oyster farming was introduced in the Bay in 1928 (Tillamook Headlight Herald, 1994), it has been adversely affected temporarily by sediments that burying oyster beds after major floods, overwash from the Bayocean spit breach, and pollution from waste discharges associated with increasing dairy industry and human populations within the Bay watershed. [Section III.C.]

- In recent years the commercial clam harvest in Tillamook Bay has substantially increased and now comprises nearly 90 percent of Oregon's total harvest (Johnson, 1995). [Section III.D.]

River and Floodplains

- A Native American population supported itself from and interacted within the Tillamook Bay ecosystem. An early and significant human impact on the landscape would probably have been through regular burning by the Native Americans to maintain valley and upland prairies for the purpose of increasing access to game and promoting the growth of other herbaceous food sources (Winters, 1941 and Botkin, 1995). [Sections III.B., III.C., V.B.]

- In the first 50 years of contact by Europeans prior to settlement, the Native American population in the Pacific Northwest was decimated by disease (U.S. Army Corps of Engineers, 1975) — possibly allowing the extension or re-establishment of forests on the lowland floodplains during the period from the late 1700's to 1850 because the frequency and extent of burnings done by Native Americans were reduced (Botkin, 1995). [Section III.B.]

- Significant declines in the salmon catch in Tillamook Bay were first observed in the 1940's (Tillamook System Coho Task Force, 1995). This overlapped with a general decline in the ocean fishery that started in the 1930's (Lawson, 1993). [Sections III.D., III.F.]

- Since the period of Euro-American settlement in the 1850's, the lowland forests and riparian woodlands have been cleared and wetlands drained and diked. From this time on, human interventions began to substantially alter the physical, biological, chemical and ecological processes that had sustained the functioning of the ecosystem. [Sections III.E., IV.B.]

- Natural wood jams near the mouths of rivers discharging to the Bay were cleared in the late 19th century for navigation purposes. The clearing of these natural wood jams would probably have reduced the frequency of floodplain inundation during flood events, increasing river channel scouring and altering or eliminating tidal aquatic habitat, including salmonid rearing areas. [Sections III.D., IV.B, IV.C.]

- The cutting and clearing of trees in the valley reaches along the Tillamook Bay rivers substantially reduced source areas for large woody debris recruitment into the fluvial system. [Section V.B.]

- The construction of river levees to protect lowland pastures reduced the connectivity of natural floodplains to river channels. This separation has reduced the opportunity for sediment accumulation on floodplain areas and has probably contributed to the increased deposition of sediments at the river mouths. [Section III.E.]

- During the initial period of logging, from the 1870's to the 1920's, the lowland rivers were used for moving logs to the estuary. During this time, the use of log rafts altered stream side vegetation by river access and the mechanical erosion of channel substrate, and had substantial adverse effects on riparian channel habitat and the salmonid habitat. (Farnell, 1980). [Section III.C.]

- There has been a significant reduction in river channel complexity — the pools, riffles, overhangs and backwater channels — that provided good rearing habitat for salmon during the period from about 1860 to 1937 — the date of the first aerial survey (Benner and Sedell, 1987). [Sections III.E., IV.]

- By the late 1920's, the majority of the Tillamook valley, used for dairy farming, had been cleared and drained (U.S. Department of Agriculture, 1952) [Section III.D.].

Watershed Uplands

- During the 19th century, there were repetitive fires in the watershed. These burns temporarily reduced the moisture holding capacity of the uplands and increased erosion and sediment delivery to the estuary for periods of time until the vegetation can recover. [Sections III.E., IV.B.]

- In 1933, a major fire burned about half of the estuary watershed. Intensive salvage logging started in the 1930's and continued for about 20 years, peaking in the early 1950's. The salvage logging delayed immediate large-scale efforts for reforestation and the associated access roads and stream crossings have created and increased a continuous potential for landsliding and sediment delivery to the estuary (Federal Emergency Management Agency et al, 1990 and Tillamook Bay Task Force, 1978). [Section III.D.]

- The 1933 fire, and subsequent fires in 1939, 1945 and 1951, initiated a major reforestation effort begun in 1949 and completed in 1970. Reforestation has progressively reduced soil erosion potential from its peak in the 1950's faster than natural reseeding and propagation (Levesque, 1980). [Section III.D.]

- In the 1960's and 1970's, major floods occurred, thus initiating landsliding, massive watershed erosion and significant deposition of sediment at the river mouths (Levesque, 1980 and State of Oregon Department of Geology and Mineral Industries, 1973). [Section III.E.]

III. An Environmental History of the Tillamook Bay Estuary and Watershed

This narrative describes the natural physical processes and human interventions that have shaped the landscape of the Tillamook Bay and its watershed over time. In order to provide an historical understanding of the ecosystem prior to settlement and during the sustainable existence of the Native Americans, PWA researched and reviewed accounts of early explorers to the region. This narrative encompasses a history of land use change —beginning with the Euro-American settlement in 1851— and illustrates the resulting impacts and environmental responses.

A. Geomorphic History

The location of Tillamook Bay on the Oregon coast is a dynamic setting for the evolution of coastal landforms . Along the Pacific coast, the subduction of the Juan de Fuca plate, located under the North American plate, has resulted in subtle and violent changes to the regional coastal landscape throughout time. Climatic changes resulted in rapid and gradual changes to sea level and the weathering of the land masses. As the ecosystem experienced changes in the dynamic equilibrium of natural forces — brought on by climate change and catastrophic natural events — the continual erosion of sediment from the Bay watershed and deposition of the sediment in the estuary has alternately been both slowed *and* accelerated over time.

Sea Level Rise

About 12,000 years ago the level of the sea began to rise dramatically. Prior to this time, continental glaciation had maintained sea levels more than 100 meters lower than today (National Research Council, 1990). With the melting of the European and North American ice sheets, the sea level increased above current elevations and began changing the natural processes of erosion and deposition, thus shaping the landscape along the continental coasts. Figure 1 shows an interpretation of sea level rise during Holocene times. Core samples from what is now Tillamook Bay indicate the gravels and sands deposited were submerged by the rising seas and covered by encroaching ocean sands. Weathering in the upper watersheds and the transport of eroded sediments by the coastal rivers continued unabated, but estuarine silts and clays became the dominant deposits in the drowned river mouth (Glenn, 1978).

Approximately 6,000 years ago, the rate of sea level rise and the rate of sediment input to the Bay from ocean sands slowed (Glenn, 1978). A form of dynamic equilibrium developed amongst ocean wave action, longshore transport of beach sands and ebb tide scouring of the estuary. A predominant northern longshore drift of beach sands developed and the Bayocean Peninsula formed along the coastline to a point where the ebb tidal discharge from the Bay deflected the drift back into the ocean. The estuary then evolved a dynamic equilibrium form: sedimentation filled the deeper areas until water depths became shallow enough for wave action to continually resuspend sands and muds. These were then discharged from the estuary on the ebb tide. Core samples taken throughout the Bay indicate that the rate of riverine sediment deposition into the Bay has been fairly steady for the past 5,000 to 3,000 years (Glenn, 1978).

Earthquakes

The discovery of buried marshes along the Oregon coast, and in Tillamook Bay, suggest cycles of slow coastal tectonic uplift followed by rapid submergence of the land (Madin, 1992). The number and sequence of these buried clues indicate catastrophic earthquakes as the agent for land subduction. These earthquakes occurred over the past 4,000 years at intervals of 300 to 1,000 years, with the last event about 300 years ago (Komar, 1992). Twentieth century surveys of land along the Oregon coast suggest that uplift in the Tillamook area is relatively less than along other portions of the coast (Figure 2). Therefore, the effect of sea level rise may be more pronounced over time in the Tillamook vicinity because a negative rate of elevation change, relative to sea level, indicates land inundation by a rising sea (Komar, 1992).

Floodplains and Rivers

Throughout the prehistory of the Tillamook Bay region — and to the present day — climate and weathering shaped the landscape and cause continual changes to the Bay ecosystem. The upland erosion of soil from rainfall and transport of sediment and woody debris from runoff has contributed to the evolution of the valley floodplains and the complex river patterns. The interaction of seasonal river floods and low flows with the tidal cycles and episodic seismic events has added complexity and historic change to the river floodplain and estuary margin. These processes have resulted in the formation of freshwater and saltmarsh wetlands, distributary river channels and sloughs, and tidal channels.

The hydraulic connection of the rivers to the floodplains sustained each of these parts of the valley landscape separately and together. Overbank flood flows and rainfall replenished floodplain soils and recharged alluvial aquifers. Seepage from riverbanks supplemented summer lowflows and perched water tables sustained floodplain wetlands.

Within this highly complex and continually changing fluvial system, salmon evolved; they adapted to the seasonal variations in habitat food sources and the spawning passage that confronts each generation. Eroding streambanks contributed organic matter in the form of fallen trees and the trees, in turn, provided cover for habitat. Water flow patterns continually changed in response to these floodplain margin changes and presented complex conditions in substrate gravels and channel shape. It is both interesting and important to note that the species in peril today — the salmon population — evolved over time in the most dynamic part of this watershed ecosystem by adapting to natural changes.

B. The Native American Landscape (Before 1800)

The condition of the Tillamook Bay ecosystem prior to the 1800's is not well documented because Euro-American exploration was sporadic and settlement came late to this portion of the coast. Our understanding of the natural environment and the level of human intervention at this time is limited to the written accounts of early explorers and research into the Native American culture.

Accounts of the Early Explorers

The early exploration of the coast at the Tillamook Bay entrance in 1778 is ascribed to John Meares, a fur trader and former lieutenant in the British navy (Elliot, 1928). Although Captain James Cook explored the north coast of the continent in 1778, apparently bad weather had kept him from approaching the coast which Meares was able to explore ten years later. As Meares sailed south along the coast, he noted a change in the coastal landscape just south of Tillamook Head.

> "The face of the country, however, assumed a very different appearance from that of the Northern coast. Many beautiful spots, covered with the finest verdure, solicited our attention; and the land rose in a very gradual ascent to the distant mountains, skirted by a white sandy beach down to the sea. As we sailed along, spacious lawns and hanging woods everywhere met the delighted eye, but not a human appeared to inhabit the fertile country of New Albion."

This portion of the coast is believed to be in the vicinity of Seaside to Columbia Beach. The mention of "spacious lawns" and "hanging woods" gives some insight to the landscape at this time and it is interesting to envision alternating prairies and forests.

It is Meares who named Tillamook Bay *Quicksand Bay* probably because of its extensive exposed sand flats at low tide. However, this statement could be consistent with the observation of a large extent of tidal mud flats at low tide. On Sunday July 6, 1788, Meares and his crew approached the entrance to the Bay from the north and he recorded this entry in his journal:

> "As we thus pursued our course along the shore, observing every part of it with the most minute attention, a large opening appeared a-head, which once more animated our hopes, and formed a new

source of disappointment. In the offing it blew very strong, and a great westerly swell tumbled in on the land. By seven o'clock we were a-breast of this opening, the mouth of which, to our great mortification was entirely closed by a low, sandy beach, nearly level with the sea, which appeared to flow over it, and form an extensive back-water — beyond it an open champaign country extended a considerable distance, where it was confined by a boundary of lofty mountains."

Having observed the conditions at the mouth of the Bay, they were convinced there was no opening into *Quicksand Bay*. However, the observation of "an open champaign country" implies a broad expanse of open countryside was seen from the coast. Given the topography of the land along the eastern shore of the Bay, it is likely that by looking across the southern end of the peninsula, Meares observed the floodplain valley in the southern portion of the Bay.

About one month after Meares' observations, on August 14, 1788, the sloop *Washington* under the command of Captain Robert Gray entered Tillamook Bay. Although they observed a bar with breaking waves, the ship navigated the entrance without encountering less than two and a quarter fathoms of water (Elliot, 1928). Their first attempt to leave the Bay on August 16th was thwarted by a strong flood tide and calm weather, rendered their sails ineffective and threatened to sweep them onto a "reef of rocks."

While waiting for the tides to change, a crewman got into an altercation with the Native Americans and was murdered within sight of the remaining crew. This incident resulted in the name *Murderers Harbour* for Tillamook Bay. The entrance to the newly named place is described by Haswell, one of Gray's officers who kept a log of their journeys:

> "Murderers Harbour, for so it was named, is I suppose the entrance of the river of the West it is by no means a safe place for aney [sic] but a very small vessel to enter the shoal at its entrance being so aucwardly [sic] situated the passage so narrow and the tide so rapid that it is scarce posable [sic] to avoid the dangers."

In "the entrance of the river of the West," Gray and his crew mistook the Tillamook Bay for the entrance Columbia River. On August 17th they made a second attempt to leave the Bay and became caught in an ebb tide and rising surf that nearly flooded their sloop. They anchored the sloop against the flood tide and finally exited with the next ebb tide.

During the winter of 1805-1806 Lewis and Clark were at Fort Clatsop near Astoria. A report of a beached whale south of Tillamook Head peaked Clark's interest and he set out with twelve men to find the whale with the dual purpose of obtaining some whale blubber and learning more about the countryside south of the fort (Thwaites, 1905). One of the mandates given to Lewis and Clark by President Jefferson was to document the conditions of the country they traveled. Along this particular trip, he used a key observation point — a promontory located on Tillamook Head — from which there he could see the Tillamook Bay area. There is a common misunderstanding that Cape Falcon was formerly known as Clark Point of View. Original maps from the Lewis and Clark expedition confirm Clark's viewpoint to be on Tillamook Head (McArthur, 1992).

Although Clark did not reach Tillamook Bay — his southern most destination was the Nehalem River where the whale was found — his descriptions of the area and his conversations with the Native Americans are noteworthy for a reconstruction of the coastal ecosystems. Traveling south he crossed the Neah-Hoxie River—now the Necanicum River—and described it as entirely bordered by overhanging trees (Bancroft, 1884). In the Nehalem watershed, he described the mountains as "covered with a verry [sic] heavy growth of pine & furr [sic], also the white cedar or arbor vita and a small proportion of the black alder, this alder grows to the height of sixty or seventy feet and from 2 to 3 feet in diamiter [sic]." Along the coastline north of the Nehalem River and south of Cape Falcon he noted tremendous landslides had occurred probably due to the heavy rainfall "fifty or a hundred acres at a time give way and a great proportion of an instant precipitated into the ocean."

In communicating with the Native Americans through hand-signing, he learned that most of the Tillamook nation lived in three large villages at the entrance of three rivers that fell into a bay. The nation was very large and they had many houses. During salmon season many fish were caught in the small creeks and when salmon were scarce they "found sturgeon and a variety of other fish thrown up by the waves and left by the tide which was verry [sic] fine."

The Native American Population and Culture

Through the first half of the nineteenth century, the Tillamook Indians experienced a dramatic decline in population. This was attributed largely to small pox and other diseases, with the earliest occurrence of small pox along the central Oregon coast believed to be before 1789 (Taylor, 1974). The Chinook tribe was decimated by an epidemic of "fever and ague" between 1829 and 1832, losing up to 90 percent of their population. This disease may have spread south to the Tillamook Indians, thus furthering their demise. An interesting note was made in the historical record concerning the 1829 epidemic: the outbreak of the epidemic coincided with the year in which the fields were first plowed. It was speculated that there was some connection between breaking up the soil and the fever (Taylor, 1974). Lewis and Clark estimated the Tillamook Native American population was about 2,200 in 1806, and that by 1849, it had decreased to 200 (U.S. Army Corps of Engineers, 1975) because of disease —most of which was introduced by contact with EuroAmericans (Figure 3).

Archeological investigations in the 1950's identified ten Native American villages along the shoreline of the Bay and the river delta areas (U.S. Army Corps of Engineers, 1975). The earliest known Tillamook village site is carbon dated at 1,000 years old. Native American trails became the trails of the settlers (Dicken, 1978) and eventually some of these trails led to the current day road alignments. Inland travel was limited due to steep terrain and thick forests, but travel along the coast between Tillamook Bay and as far south as the Salmon River, was relatively easy because of the open prairies and sandy beaches.

Because of the vast resources of fish, crab, berries, roots and game, the Tillamook Indians had no need for agriculture. Shellfish were plentiful in the mud flats of the Bay; the villages were oriented towards the water. Hunting game and gathering were done close to the villages and along the nearby open lowlands (Taylor, 1974). When fishing waned expeditions were made into the interior to supplement food stores — but the hunter's routes followed the river courses. The Native Americans did not frequent the upland forested areas as they had no need to (Taylor, 1974); it is believed that the Tillamook Indians limited their exploration to the tidewater portions of the rivers along their coast. Hunting for larger game also was kept close to the Bay and rivers because game was plentiful there and the Native Americans would not want to pack out deer or elk killed farther inland.

Early Accounts on the Use of Fire

In the 1820's, the botanist David Douglas — whose name is associated with the Douglas fir — provided the earliest documentation of forest fires as seen by settlers in the Pacific Northwest (Morris, 1934). Specific references to nineteenth century burns in the Tillamook area were recorded by the Oregon pioneer Jesse Applegate. He observed that the Tillamooks, along with most of the other Native American tribes, had a custom to "burn off the whole country" late in the autumn every year after the wild wheat was up, so that the squaws could readily gather the grain of tar weed. Early pioneers were attracted to the prairies in the both the floodplain and the higher elevations of the Tillamook area (Dicken, 1978). The fact that prairies existed prior to settlement may be an indication of earlier burning by the Native Americans (Figure 3). The Native Americans were also reported to have set fire to acres of old growth spruce and fir to make pasturage for their ponies (Winters, 1941).

The settlement of fertile plains in the mid 1800's by EuroAmerican settlers stopped the annual burnings of the river valleys in Oregon by the Native Americans: the settlers did not want new crops or buildings to be jeopardized by fire. However, research of timber age class in the 1930's period indicated that even following

EuroAmerican settlement, forest fires still consumed increasing amounts of land. In the 1960's, nearly all of the commercial timber in the North Coast was determined to be less than 100 years old (USDA, 1966).

C. The Era of Settlement (1800-1900)

The Unpopulated Wilderness Landscape

The early explorers' accounts of entry into Tillamook Bay focused on the hardships of entering the Bay and interactions with the Native Americans rather than upon the landscape. However, as settlers arrived, they were drawn to the prairies in the Tillamook area. These grass- and fern-covered prairies proved relatively easy to cultivate (Dicken, 1978). These prairies appear to have been remnant features of the valley landscape that was formerly controlled to a certain extent by Native American burnings. Extensive forests with dense undergrowth made the land beyond the prairies difficult to clear for farming and grazing.

It is believed that the name "Tillamook Bay" is first mentioned in the book, *Oregon*, published in 1857 by A. N. Armstrong, a government surveyor in Oregon (Holman, 1910). During the early 1900's, settlers had a clever way of remembering the layout of the Bay and rivers (Strite, 1971):]

> "To fix the location of the rivers into the bay, Uncle John had me extend my right hand, palm down, to the south. The thumb was the Miami which flowed into the bay near Garibaldi. The index finger was the Kilchis which entered the bay near Idaville. The middle finger was the Wilson, the ring finger the Trask and the little finger the Tillamook."

Settler C.F. Coan's description of Willapa Bay — known as Shoal-water Bay in the 1800's — lends insight as to the riparian conditions of Tillamook Bay prior to settlement (Coan, 1921). He describes it as having "extensive and beautiful groves of fir and cedar, with small prairies interspersed; there are also large tracts of what is called 'hardwood bottoms'." In "A Geographical Sketch of that part of North America called Oregon," published in 1830 by Hall J. Kelly, the Tillamook River is described as a "river one hundred yards wide, has no falls, and no difficult rapids" (Holman, 1910).

The early donation land claim settlements southeast of Bay City were located along the western edge of the plain areas. This suggests that the early settlers were as involved with fishing as with agriculture (Dicken, 1978). Settlement beyond the early land claims grew slowly because access to the area was limited — but by the late 1800's and early 1900's, nearly all tidelands adjacent to the Bay shoreline were in private ownership (Thos. J. Murray & Associates, 1982).

Figure 4 is a reconstruction of the Kilchis River Valley floodplain in 1856-57, based on the original survey notes for the donation land claims. In addition, Section V provides a characterization of the entire Tillamook valley historic landscape as developed from these same survey notes.

Up until the turn of the century, the tidelands around Tillamook Bay were forested with large amounts of Sitka spruce and Western hemlock (Strite, 1971), and giant spruce grew on the river flats within seven miles of Idaville (Strite, 1971). During World War I, a high demand for spruce for airplane stock to an extensive harvest of the tideland forests. Hemlock was considered a "weed-tree" and was rarely cut. An account of life on the Bay in 1919 describes the shoreline beaches of the Bay as covered with driftwood (Strite, 1971).

Historic accounts of the Bay shoreline between Bay City and the vicinity of Idaville in 1919 indicate the area was vegetated with scrubby spruce and hemlock and thick understory growth of alder and berry bushes (Strite, 1971). In the same account, the shoreline opposite Idaville — two miles across the Bay to the southwest, along the southern portion of the spit — is described as having "wooded hills looming over shallow water." Pacific coast trees are very sensitive to climate. Sitka spruces, western red cedars and hemlocks tend to thrive in wet, foggy coastal river valleys and are susceptible to fire (Norse, 1990). Unlike the Sitka spruce, the cedar and hemlock also survive in drier lowland areas.

Forest Fires

There is much debate concerning the history and causes of forest fires in the Pacific Northwest. Anecdotal accounts provide both insight and confusion on specific burns. A regional viewpoint places anecdotal evidence in a better perspective. Figures 5a to 5d are a set of maps based on U.S. Geological Survey land measurements. Burned areas in the Tillamook Bay watershed area are not evident until the 1940 mapping. However, in 1850, the area of 100- to 200-year growth in the southern part of the watershed indicates possible fire disturbances dating back to the mid 1600's. The mapping suggests that the Oregon coast was a matrix of forests of different ages prior to Euro-American settlement and — through burnings — illustrates the significance of human influences on the landscape (Botkin, 1995).

Natural stands of Douglas-fir in the Tillamook Bay watershed may also indicate a revegetation process controlled by fire. Douglas-fir are dependent on fire to establish themselves: seedings germinate better on mineral soil, as opposed to forest litter, and grow better in sun than in shade. Mature Douglas-fir have a thick bark and deep root system. This system makes them less susceptible to injury and death from fire than the Sitka spruce, western red cedars, western hemlocks, and firs — all of which are characterized by thinner bark and shallower root systems (Norse, 1990).

Many of the forest fires in the late 1800's were a distance from settlements and were attributed to smoldering camp fires; both intentional and unintentional fires were set. During land clearing, early settlers burned slash to prepare the land for agriculture. These slash fires were often set during the most fire-prone time of the year in late August and September and resulted in uncontrolled fires.

The fire of 1845 is one of the earliest documented major burns (Johannessen, 1961). It started in the Willamette River basin near Champoeg in Marion County . For several weeks, the fire burned in the Willamette Valley before crossing the coast range and driving Native Americans coastward to Nestucca Spit and Sand Lake. A comment in *the Oregonian* newspaper's account of the fire, dated August 31, 1894, sheds additional light on the frequency of fires prior to European settlement: "The fallen debris previous to the fire was undoubtedly the accumulation of a century."

The first white settler arrived in Tillamook in 1851 (Tillamook County Pioneer Association, 1979). After 1851, fires in the Tillamook area were documented in greater detail. The big fire in the summer of 1868 started in Clatsop County and was swept south by strong north winds (Tillamook County Pioneer Association, 1979). The fire burned areas at higher elevations of the Coast Rang, located back from the beach and bay. Indians and settlers said it was the largest fire they had seen in their lifetimes.

The General Land Office original township survey notes provide a portion of the burn history. The first survey was done in the 1850's and focused only on the lower valley areas associated with the Tillamook Bay and river bottom lands. It included some of the foothills and the exterior (or township lines) in the mountainous areas. However, the majority of the mountainous lands were not surveyed until the 1880's. The 1856-57 survey work reported a few burned areas in the lower mountains around the Bay (Plate 1). Overlap of the early and later survey work shows an increase in burned areas from the to 1850's to 1873 and 1884.

In 1908, a timber cruise was conducted in the Tillamook Bay watershed for the purpose of assessing the species, condition and extent of marketable timber as well as the physical conditions for logging and removing cut logs. These foresters also noted soil conditions and the land areas damaged by fire. Their findings are published in a two-volume document titled the 1908 Tillamook County Timber Cruise, available at the Tillamook County Pioneer Museum. Included in the timber cruise documentation are individual 40-acre parcel sketch maps for every township section within the Tillamook Bay watershed. These maps were used to create a map (Plate 2) that reconstructs the landscape at the turn of the century as viewed by the foresters. -Several foresters participated in the timber cruise, and consequently, the level of detail, style of comments and thoroughness of accounts is varied. These comments are summarized on the inset Table of Plate 2.

Whilst mapping the burned areas in 1908, some foresters actually sketched out the estimated boundaries of burn areas and others generally noted burn conditions for the entire section. In many instances, foresters differentiated between areas of burn and old burn. Although they did not make specific estimates as to the dates of the old burns, it can be reasonably assumed that these fires occurred in the 19th century. The original township survey notes appear to substantiate this. The following findings can be surmised from Plate 2:

1. Large portions of the Kilchis, Wilson and Trask River valleys had been burnt by the turn of the century;

2. Several of the bums appear to be associated with clearing activities for Euro-American settlements and are typically located along the major rivers and wagon roads;

3. Large portions of the Wilson and Trask River valleys were ranches without timber by the turn of the century;

4. A majority of the first farms were established in the lower portions of the Kilchis and Wilson River valleys; and

5. Several areas of windfall were documented along the coast line of Netarts Bay and indicate significant windstorms had buffeted the coast.

Figure 6 maps the nineteenth and early twentieth century forest fire locations recounted by settlers and Native Americans. Even with such documentation, a great deal of speculation still exists as to the accuracy of forest fires accounts — exaggerations , story telling, and faded memories affected Native Americans and settlers alike. A large area in the south portion of Tillamook County was burned around 1845. However, based on its proximity to the outline of the 1933 burn, this burn was predominantly within the Nestucca River watershed and appears to not have entered the Trask River watershed. Other accounts of great fires in the coast range were located south of Tillamook. More localized fires were reported in 1902 along the Wilson River.

Into the 1900's, there was no organized approach for fighting fires — fires could spread uncontained from their source. In many instances, previously burnt timber provided fuel for the next fire.

Early Industries of Farming, Fishing and Logging

Settlers came to the Tillamook area primarily to farm: the combined maritime climate and weathering of the uplands provided good soils. Farming became well established soon after settlement and farm property values increased rapidly from 1850 to 1860 and more slowly to 1870, due to the Civil War (Swift, 1909). The number of farms and their value continued to increase through the late 1800's (Figure 7), but after 1900 the land area in farms for Tillamook , as well as Oregon in general, began to decrease (Swift, 1909).

By 1900, Tillamook County had one of the highest number of owner-operated farms in the state. This was attributed to the newer and more isolated farming conditions found in the Pacific Northwest coastal counties (Swift, 1909). The reduction in the land area in farms since 1900 (Figure 7) can be attributed the increasing value of timber and the subsequent sale of range and forested farm lands to timber companies (USDA, 1966). This change from agriculture to forestry was more pronounced for Oregon than the other western states (Swift, 1909).

Logging was not considered an industry during the early period of settlement in the county. In the 1860's, land along the Bay was being cleared and "timber was only a nuisance" (Strite, 1971). Trees were viewed as obstacles to the development of pasture lands and were felled and burned or taken to the tidelands to be washed away by the tides (Tillamook County Chamber of Commerce, undated). Three small sawmills did start operations in 1863, but all closed by 1870 (Figure 8). These early sawmills were water powered and one-person operations, run solely to meet the local building needs (Levesque, 1985). The longer-lived sawmills started around 1880. In the summer months, cut logs were pulled to mills by oxen; the logs were sawn into lumber during the winter rain season. Logging continued into the foothills along the major rivers and log drives were used to move cut timber to the valley sawmills.

A detailed description of log drives and splash dams on the Tillamook Bay rivers is found in the document Tillamook Bay Rivers Navigability Study (Farnell, 1980). The objective of this report was to clarify the boundaries of state ownership of the navigable portion of the Tillamook Bay rivers. The ownership of these river reaches transferred from the United States government to the State of Oregon in 1859. T he report indicates that the use of rivers for log drives determined the state's claim to the beds of navigable rivers draining into Tillamook Bay above the head of tide. Table 1 summarizes the navigable portions of these river based on this criteria.

Figure 9 shows the location of splash dams and the river reaches used for log drives on the Tillamook Bay river from 1880 to 1910. It is interesting to note that — unlike in other Oregon coastal areas — nearly the all dams were located on Bewley Creek, a tributary to the Tillamook, whereas few splash dams were in the basin (Sedell and Duval, 1985).

Historic photographs document the massive numbers of cut logs choking a reach of river during a typical log drive (Figure 10). There are records of lawsuits brought by riparian owners for damages along the banks of river properties and for the obstruction of boating caused by log drives (Farnell, 1980). It is implied that river bank damage was caused by sending two years' cut of logs down the river at the same time — the backlog of timber from the previous year *and* the current year's supply. Damages are not specifically described, but one can envision that in the riparian portions of the corridor, river access altered streamside vegetation and log rafts caused a mechanical erosion of channel substrate. Log drives during high water events on the rivers proved to be a cost-effective way to move the logs downstream under their own power during floods.

Table 1
State of Oregon Claims to Navigable Tillamook Bay Rivers

River	River Miles	Period of Log Drives
Kilchis (a)	0-3.5 (head of tide)	1872-1915
Trask	0-10	1879, 1890-1915
Tillamook	0-6.7	1887-1915
Bewley Creek (Tillamook)	0-3	1892-1915
Wilson	0-22.5	1893-1908
Miami (a)	0-1 (head of tide)	1900-1920

Source: Farnell, 1980 except (a) no factual evidence of log drives upstream of the head of tide.

The flooding and release of water from behind man-made splash dams and log jams may have caused more riparian damage and accelerated sedimentation Beginning around 1900, splash dams were used on the steeper portions of river reaches as a means to sluice logs downstream in any season of the year. One such dam, constructed on Bewley Creek in 1900, was described as being 200 feet long, with an 11 foot gate and containing a 17 foot head of water (Columbian River and Oregon Timberman, 1900). Splash dams were primarily used in the summer low water months as ample water was available through the winter to move the logs downstream without the dams. The dams would create stair steps of pooled water down the steeper river reaches and the logs would be moved downstream by releasing water through the gates. This activity caused small freshets of streamflow to occur. The frequency, duration and location of these "splash dam freshets" — in combination with the naturally occurring winter freshets — probably altered the morphology of the downstream river reaches and accelerated sedimentation during and after the time period of their use.

Fish and shellfish — clams and crabs — had always been plentiful for the settlers and Native Americans and a small export soon developed to San Francisco (U.S. Army Corps of Engineers, 1975). The first cannery was constructed in Hobsonville in 1885 and stimulated a small commercial fishing industry. Cannery pack records began in 1892 for Tillamook Bay and imply early coho landings. However, not all of the fish canned at one location were necessarily caught at the same location. Harbor navigation improvements were completed by 1905 and aided the export business, but the hazardous Bay entrance still made shipping of canned salmon, as well as other products, uncertain.

Recreational and commercial net fishing has occurred in Tillamook Bay since the 1800's. Gillnet fisheries began in the late 1800's and continued until 1961 (Tillamook System Coho Task Force, 1995). Commercial fishing of coho was regulated as early as 1892. These early restrictions primarily involved seasonal and occasional weekend closures (Mullen, 1981). By the 1900's, fishing on most Oregon rivers became less restrictive with a change from 70 to 80 days per year to 100 days.

Historic information on the shellfish industry in Tillamook Bay is limited prior to the 1960's, harvests were rarely documented (Johnson, 1995). Oysters are not native to Tillamook Bay: they were first planted in the Bay in 1928 by Jesse Hayes (Tillamook Headlight Herald, 1994). Early shipments of oysters from Tillamook Bay to San Francisco in 1862 likely involved oysters harvested from Netarts Bay and brought over to the port at Tillamook (Jensen, 1995).

A regional history of the oyster industry provides valuable information for the other ecosystems and may be useful in assessing current and future influences on the oyster harvest in Tillamook Bay. This historical insight into the oyster industry on the Pacific coast is described in a U.S. Government document published in 1881 (Ingersol, 1881).

During the early 1800's, oysters grown in San Francisco Bay were harvested for local consumption — but they were smaller than their east coast counterparts and not held in high regard. In March of 1850, larger oysters were discovered in Shoalwater Bay in Washington State — now Willapa Bay — and were then exported to California and coastal communities in Oregon. Oyster harvesters in Shoalwater Bay accelerated the harvest by raking the oysters off of their natural beds and placing them in staked-out beds closer to shore. Similarly, some of the wild oysters were taken to San Francisco Bay and transplanted there (Ingersol, 1881).

In the 1860's, a series of natural disasters decimated the oyster industry in San Francisco Bay, thereby creating more of a demand for Pacific Northwest oysters. A major flood on the San Joaquin and Sacramento Rivers killed off nearly all of the oysters in the Bay with an influx of fresh water and mud in 1862. In 1867, a blight attacked the San Francisco Bay oysters, causing them to "shrivel up as though cooked." Finally, the great earthquake of 1868 caused a "heating of the bottom" of the Bay, killing the oysters. An observation at the time of this earthquake noted that the thin-shelled western oysters were killed but the transplanted thicker-shelled eastern oysters survived. These repetitive disasters led California to import oysters from the Pacific Northwest and, with the completion of the trans-continental railroad, from New York as well (Ingersol, 1881).

In 1862, an Oregon newspaper article announced the shipment of 3,000 baskets of oysters from Tillamook Bay to San Francisco (Oregon Statesman, 1862). As there is no evidence of oysters in Tillamook Bay at this time, it is believed the oysters were harvested in Netarts Bay and simply shipped from Tillamook Bay (Jenson, 1995). By the 1870's the quality and number of the Shoalwater Bay oysters began to decline.

> "...the Shoalwater Bay oyster beds have largely ceased to be productive, and such oysters as are got are of poor size and flavor. What is the cause of this sudden and excessive decay of the Shoalwater oyster beds, no one can say. Of that stock which is planted three-fourths now dies."

The mention of a "sudden" change to an early oyster industry in the Pacific Northwest (Ingersol, 1881) indicates that the productivity of this type of fishery is historically vulnerable to changes from natural influences.

Early Navigation and Roads

The abundant natural resources from the Tillamook Bay ecosystem and the increasing market for them outside of the area resulted in the need for reliable transportation for commerce. The isolation of Tillamook from the rest of Oregon forced merchants to rely on shipping to maintain and increase the economic viability of the Bay area. Early navigation projects were performed by the Corps of Engineers for this economic purpose, as well as to maintain a navigable harbor and entrance channel for the fishing industry. Before 1913, the Port of Tillamook maintained a shallow-draft channel as far as Tillamook City for ocean going ships (Thomas J. Murray & Associates, 1960). The River and Harbor Act of March 2, 1919 resulted in the abandonment of the channel upstream of Bay City for navigation maintenance (Thomas J. Murray & Associates, 1960).

After the first soundings of the Bay were completed in 1867, the Corps of Engineers determined that no navigation improvements were necessary to the main tidal channel leading to the Bay entrance. However, since the better timber was now located further up the rivers, channel improvements were called for along the upper estuary and river channels so that deeper draft boats could ply the waters laden with lumber (Figure 11).

Some of the early roads in Tillamook County evolved from the trails of the Native Americans. Settlers came to the area either from the north — on land routes from Astoria — or from the south — across the Coast Range from the Yamhill River drainage to the Nestucca River drainage and north to Tillamook (Dicken, 1978). One of the first accounts of a concerted effort to clear a trail was along this southern route. The people of Tillamook began the clearing from the coast and the Willamette Valley settlers began the clearing from the interior (Dicken, 1978). This route eventually became the stagecoach road that connected the Tillamook area to Portland over 90 miles of rough travel (Strite, 1971).

Several toll roads were constructed in the late 1800's including the Trask Toll Road opened in 1871, the Tillamook and Nestucca via Beaver Toll Road in 1883, and the Wilson River Toll Road in 1893 (Oregon Department of Forestry, 1993). Until 1911 and the advent of the railroad, the only land route from Tillamook to Portland was the widened and improved old stagecoach road (Strite, 1971).

Climate Records Begun

Although continuous precipitation records for the Tillamook area were not kept until 1933, records from Newport, Oregon were adjusted to represent precipitation in Tillamook County, beginning in 1889. The desire for local information on rainfall was driven by an evaluation of potential water power reservoir sites along the coastal ranges and possibly by the growth of agriculture in the region and the resulting need to understand seasonal weather changes for better crop and dairy management.

Figure 12 shows historic trends in rainfall and temperature at Tillamook for the period 1933 to 1992 (Taylor, 1995). An inset table provides tabular data on annual precipitation for the period 1889 to 1920 (Jones, 1924). It is interesting to note that monthly precipitation estimates for the last part of the 1800's and early 1900's show relatively high amounts of annual precipitation relative to later years in this century. This condition may be attributed to wetter weather years at the turn of the century and/or errors in the transfer of precipitation data from Newport to Tillamook.

D. The Managed Landscape (1900 to the Present)

Farming

At the turn of the century, most of the lowland forest areas had been cleared and stumps removed to make room for more farms. In 1913, the Tillamook Clay Works was established to supply clay tiling to farmers. Tiling allowed them to drain wetlands in order that dairy herds could be turned out to pasture earlier in the season (Tillamook County Pioneer Association, 1979).

A summary of agricultural statistics for Clatsop, Columbia and Tillamook Counties indicate about half of the farmers worked part-time on their farms up to the 1950's and that the timber industry was the major source of off-farm work (USDA, 1966). Since the timber industry faced seasonal and cyclical periods of employment, small acreages were purchased for farming in times of timber unemployment (USDA, 1966). This trend is probably reflected in the continued increase of number of farms in the county through the 1940's. The sale of forest and range lands to timber companies in the 1940's, and the conversion and combination of part-time farms to larger commercial farms in the 1950's, reduced the number of farms in the Tillamook area (USDA, 1966).

Drainage of Agricultural Lands

Beginning in the early 1900's, drainage and diking districts were formed to legally sponsor measures to reduce the flooding of valley areas. A reduction in flooding meant that more pastures could be could be maintained as productive dairy land. Approximately 4,600 acres of the south Bay were intended to be protected from flooding by a system of dikes and drainage ways (Levesque, 1980). It is believed that many more areas of land are protected by dikes and levees without legal sponsorship (Levesque, 1980). For the purposes of this discussion, a dike is defined as a wall built around a low area to prevent flooding and a levee is defined as an artificial mound built along a river to confine the area of flooding (American Geological Institute, 1976).

According to the 1950 Agricultural Census (U.S. Department of Agriculture, 1952), drainage enterprises increased from 10 to 29 in Tillamook County between 1940 and 1950. By 1950, 22 of the 29 drainage enterprises were irrigation enterprises draining 284 acres. The remaining 7 drainage districts drained a total of 5,643 acres. Table 2 provides a summary of the time periods in which these districts were organized and the amount of land drained for agricultural purposes. This summary indicates the first drainage districts were formed in the early 1900's and a majority of the Tillamook valley land area used for farming had been cleared and drained by the late 1920s (U.S. Department of Agriculture, 1952). The land area drained as other drainage districts formed in the 1920's and 1940's was significantly less than in the period 1910-1919.

Under the auspices of the 1948 Flood Control Act, the Corps of Engineers added a levee for the Stillwell Drainage District and repaired lengths of levee along the Wilson and Kilchis Rivers as an emergency flood control activity. As of 1980, no new levee or dike construction was proposed (Levesque, 1980).

Table 2
Time Periods for Drainage District Organization and Acres Drained

Time Period	Drainage Districts Reporting	Acres Drained
Before 1900	---	---
1900-1909	---	---
1910-1919	4	3,423
1920-1929	2	1,671
1930-1939	---	---
1940-1949	1	549

Source: Data from the U.S. Department of Agriculture, 1952. Drainage of Agricultural Lands, Bureau of the Census, Volume IV, U.S. Government Printing Office, Washington, D.C.

Figure 13 shows the dikes and levees in the south Bay area. In addition, a limited length of levee was constructed outside of this area on the Miami River along the east side of the railroad tracks and the north side of the river. The low dikes along the Wilson and Trask Rivers were constructed from river sediments dredged from the river mouths. Dikes in the lower portions of the Wilson, Trask and Tillamook River valley area were erected primarily to prevent pasture flooding from tidal overflow. Major flood events, such as the 1964 flood, inundated most of the valley floor (Figure 14). During the January 1972 floods, flood waters out-flanked the river dikes farther upstream and caused wide spread flooding behind diked areas (State of Oregon Department of Geology and Mineral Industries, 1972).

The Dairy Industry

Historically, the majority of the farms in the Tillamook area have been dairy farms. They are concentrated into a 35 square mile area tidewater-floodplain pasture area and typically average 100 cows to 80 to 100 acres (Little, 1989). With the establishment of the Tillamook County Creamery Association (TCCA) in 1908, the collection, production and marketing of milk and milk productions became more organized.

The number of cows and milk production increased dramatically over early trends in the 1800's (Figure 15) (U.S. Census of Agriculture, 1860 to 1992). From 1935 to the mid 1950's, the dairy industry enjoyed prosperous and steady economic conditions and milk production increased.

During the 1960's, the decline in the number of cows may be attributed to dairy farmers quitting due to the milk audit stabilization disagreements. This action established quotas for grade A milk production for each cow that buyers were willing to pay producers for. The TCCA was interested in maximizing profits for all association members and encouraged the expansion of the association to new members (Brown, 1995). The Tillamook Cheese and Dairy Association did not want to share the quotas and preferred to be a closed association. The fact that milk production continued to increase despite a reduction of cows is likely due to efforts to increase productivity.

The significant increase in milk production and the number of cows in the late 1970's and early 1980's is a direct result of increased marketing of dairy products by the TCCA. The main fresh milk market has traditionally been Portland (USDA, 1966) and the dramatic growth in population of the Portland metropolitan area has likely fueled the dramatic increase in milk demand and production since the early 1980's.

Manure Management

At the turn of the century, artificial fertilizer use was "almost unknown" in Oregon (Swift, 1909). Livestock manure was collected from stables and spread over the fields, and in many cases no action was taken to fertilize artificially. The use of fertilizers later in this century is inconsistently documented in the U.S. Census of Agriculture for Tillamook County. A trend in the application of fertilizers in the county from 1954 to 1992 is presented in Figure 16 and shows peak usage in the mid 1960's and a decline to the late 1980's and an increase again in the 1990's.

Manure management has always been a concern in the Tillamook valley. A local agricultural official described how, in the early days, farmers would take advantage of the heavy rains and build their barns to back onto the river so they could push the manure out the door where it would be carried away by the flowing waters. By 1989, a reported 19,000 cows within the Tillamook Bay pasture lands annually produced 275,000 tons of manure (Little, 1989).

Fecal bacteria contamination of bay waters during heavy rainfall first became identified in 1969 when routine water quality monitoring was begun. The Confined Animal Feeding or Holding Facilities And Operations (CAFO) rules became effective in 1972. The purpose of the rules was to "protect the quality of the environment and public health in Oregon by requiring application of the best practicable waste control technology relative to location, construction, operations, and maintenance of confined animal feeding or holding facilities and operations" (Oregon Administrative Rules, 1991).

The Rural Clean Water Program (RCWP) in Tillamook Bay began in 1981 and continued for 10 years. During this time period approximately 7 percent of the Bay watershed — 23,540 acres of primarily pasture/range lands — was evaluated and monitored for water quality improvement. Through the implementation of agricultural Best Management Practices (BMPs) over this time, water quality monitoring showed a 40 to 50 percent reduction in mean fecal coliform (National Water Quality Evaluation Project, 1988). This reduction is attributed to increasing the application of animal waste BMPs to include about 60 percent of the project area; the ultimate level is anticipated to be 90 percent.

One of the benefits of the RCWP study and funding was the promotion and construction of covered manure storage. If manure is stored, coliform bacteria begin to die off quicker than if the manure is immediately spread on a field (Little, 1989). Once it is spread, stored manure breaks down more rapidly and turns to humus faster on the fields, thus allowing cows to return to pasture sooner. If protected from rain, manure retains more of its nutrients than if it was exposed to water leaching action. It is interesting to note that these same modern dairy BMPs were promoted in an 1894 U.S. Department of Agriculture bulletin by W.H. Beal titled *Manure Management*, likely because of the value of manure for fertilizer in those days.

The Commercial Fishery

The Tillamook Bay ecosystem has historically supported abundant salmon and shellfish fisheries resources. Coho salmon were the most abundant fish species in the Tillamook basin (Tillamook System Coho Task Force, 1995). Their historic predominance in the basin and their decline in numbers over this century has been fairly well documented and has made them an indicator species for changes to the ecosystem. Figure 17 is a well known historic photograph of salmon caught in Tillamook Bay and landed at Hall Slough in 1912.

Fish hatcheries were established early in this century on rivers tributary to the Bay and continue to have a significant influence on the salmon resources of the ecosystem. The first hatchery was established on the Wilson River in 1902 and operated for two years. A hatchery was built later on the Trask River in 1906 about three miles upstream from the current hatchery (Tillamook System Coho Task Force, 1995). The present day hatchery is on the Trask River and has been in operation since 1914.

Figure 18 provides an historical view of hatchery releases of coho salmon into the Tillamook Bay system from 1908 to the present. Up until the 1930's, most hatcheries in Oregon were egg-taking stations. With the large numbers of returning spawner fish early in this century, large numbers of eggs were taken and spawned and large numbers of juveniles were released soon after they had absorbed their egg sacs. Figure 19 shows an historic photograph of the fish catching cage and racks at the Trask River fish hatchery. Hatcheries did not operate as rearing stations during these times and, consequently, there was a high mortality of hatchery-released fry because they were hungry and in poor health upon release. The concurrent ecosystem impacts to riparian and in-channel habitat, from logging, splash damming and dredging, likely increased fry mortality during the year the fish would spend in freshwater prior to entering the ocean.

Large releases of coho fry continued under these management conditions into the 1940's. Periods of low releases occurred during these years. The significantly low releases from 1916 to 1924 probably attributed to reduced hatchery personnel during World War I. By the advent of the second World War, it was recognized that the egg-taking stations were not resulting in large returns of hatchery fish. In response, hatcheries began keeping the fish and feeding them until they reached the smolt stage. It was believed that the release of fish as smolts resulted in the more mature fish spending less time in freshwater and incurring less mortality from habitat interventions. An influx of returning World War II veterans provided the manpower necessary to manage the significant increase in labor necessary for this hatchery management change.

Returns continued to be poor through the 1950's which brought about a basic realization that no one really knew what the smolts ate. The diet for smolts typically consisted of ground up condemned animal meat or fish carcasses, the use of which provided opportunities to recycle fish diseases. In 1959 the Oregon moist pellet was introduced for fish hatchery feeding. This product of Oregon State University research and Oregon Fish Commission design and testing provided nutritious and disease-free food for hatchery smolts (Graybill, 1995). The pellets resulted in hardy smolts and decreased mortality. Hatchery releases have been somewhat stabilized since the 1960's between 0.5 and 1.25 million released. An increase of fry releases in the early 1980's coincides with the start of the Salmon Trout Enhancement Program (STEP).

Commercial gillnet fishing began in Tillamook Bay in the late 1800's, but unfortunately the recording of gillnet catch information did not begin until 1923 (Figure 18). Starting in 1921 a tax was assessed on all salmon landed in Oregon (Mullen, 1981). Fish dealers were required to keep separate records for ocean troll-caught salmon and river-caught salmon. This permitted a separate view of the salmon stock in the two ecosystems, but it is believed the data were often misrecorded and in error. The gillnet catch of coho through the 1930's appears variable, but high compared to the decreasing trend after 1939. In the late 1950's an initiative petition was prepared to stop gillnetting in Oregon so that more fish would be available for the sports fishery. By 1961 Tillamook Bay was closed to commercial gillnet fishing.

Unlike the river coho fishery, the commercial ocean troll fishery for coho had few restrictions on season and no restrictions on size of catch before 1960. Landings of coho were below the long-term average for Tillamook Bay by the late 1940's and in 1961 the Bay was closed to commercial fishing. Tillamook Bay was the last Oregon coastal area to be closed, which began with the Nestucca River in 1926 (Mullen, 1981).

The close of commercial fishing within the coastal bays and rivers relocated the commercial fishery offshore and increased ocean harvests. The ocean environment and harvesting techniques were less discriminating between hatchery and wild fish and likely led to a proportionally increased harvest of wild fish. This poses a question as to where — in a given ecosystem— fishery harvesting should take place in order to protect the wild species. It could be argued that if the gillnet fishery was moved from the Bay to the head of hatchery rivers — the Trask in the case of Tillamook Bay — harvesting would be more discriminating towards hatchery fish and wild fish would have more opportunity to return and spawn in non-hatchery streams. In addition to the coho, all other salmon species have experienced a decline in catch except for fall chinook (Figure 20) which is predominantly a wildstock and is currently classified as stable (Klumph and Braun, 1995).

The early shellfish industries in Tillamook Bay primarily involved clam, oyster and crab harvesting. Clams and crabs are native to the Bay and early records of their abundance and variability in harvest are not well documented. Oysters were introduced to the Bay ecosystem early in this century. In the 1920's, Japanese oysters were received from Canada for growth testing in Tillamook Bay (Jensen, 1995). Following successful tests begun in 1928 (Tillamook Headlight Herald, 1994), the Hayes Oyster Company obtained permission from the state legislative to lease land in the Bay for growing oysters and in 1932 the first oysters were planted in the Bay. By the early 1970's, nearly 90 percent of Oregon’s oysters were grown in Tillamook Bay (U.S. Army Corps of Engineers, 1972).

The Bay also was a major producer of clams with all minor species of clams found in Oregon. Research from 1963 indicated the Bay produced more than a ton of clams per acre (Wick, 1972). Almost all of the commercial clam harvest is done by divers in the subtidal portions of the Bay. The recreational harvest of clams is limited to the intertidal portions of the Bay. A significant increase in the commercial harvest of clams —the largest part being associated with the harvest of cockle clams. Cockle clams m used for bait by the crab fishing industry, are about 82 percent of the commercial clam harvest from Tillamook Bay (Figure 21) (Johnson, 1995). Since the mid 1980's, the total Tillamook Bay clam harvest has become proportionally more of the state harvest, while the number of harvesters in both Tillamook Bay and for the state has remained similar, and decreased in 1994 for Tillamook Bay (Johnson, 1995). This means that the amount of clams taken by each commercial harvester has increased dramatically in recent years.

Logging

Logging trends are linked to economic conditions as well as to advances in the methods used to access and remove timber. In the early and mid 1800's, bull teams removed the large old-growth timber in accessible areas along the rivers. In the early 1900',s highlead logging with steam donkey and railroad access, made the interior portions of forested watersheds accessible for harvesting. Early logging was done by clear-cutting the stands of Douglas-fir by drainage basin (USDA, 1966). During and after World War II, the use of diesel and gasoline powered tractors, trucks and logging machinery made even more remote upper watershed areas accessible.

Salvage logging was initiated in the late 1930's after the Tillamook Burn and increased significantly during World War II (Figure 22). Thorough mapping of logged areas within the Tillamook Bay watershed was first done on topographic maps prepared by the War Department of the U.S. Army Corps of Engineers (1941-42). These maps were created from aerial photography flown between 1937 and 1939 and specifically show “cut over” areas (Plate 3).

An in-depth account of salvage logging operations is presented in the document “A Chronicle of the Tillamook County Forest Trust Lands” (Levesque, 1985). Salvage logging operations started in 1937 in the Miami River watershed and continued at a high level throughout 1941 to meet the needs of the war effort. After the bombing of Pearl Harbor, logging increased even more. The Wilson River Salvage Road opened in 1937 and trucks began moving a million board feet of timber daily during the peak of salvage operations. The Trask River logging road opened in 1939. Gas and diesel-fueled equipment increased the efficiency of log salvage operations after the 1939 fire. During and after the World War II period, many railroad tracks were torn up and converted to logging roads. The use of the mechanical bulldozer in later years allowed forest road building to occur on ridges with grades up to 20 percent. A significant number of roads were available into the forests after World War II and this opened up opportunities for smaller logging operators or “reloggers” and salvage logging continued until drawing to a close in 1959. This continued logging by smaller operators is believed to be one reason for a delay in reforestation efforts and extended exposure of soil conditions for continued erosion (Tillamook County Chamber of Commerce, undated).

In the early years of salvage logging, the rugged, steep terrain made construction of logging railroads difficult and this limited the number of access points to burned locations. Verbal descriptions of salvage logging road and railroad construction, available in documents at the Pioneer Museum and Oregon History Center, indicated there were many problems involved in simply maintaining the roads against the elements. Further review of old photographs of logging roads from the Oregon History Center showed that, in many cases, the easiest access to the downed timber was along the river corridors and roads were built by excavating into the hillsides and side-casting earth into stream channels.

Reforestation was begun in November 1949 and was actually hampered by salvage logging because the effort was not coordinated. Even though the State Board of Forestry became the land owner of the burned acreage, the original landowners retained title to the timber on the land and the burned snags. Timber owners were reluctant to give up their land to the state out of concern they would lose any income from salvageable material (USDA, 1966). This situation caused salvage operations to continue into the 1970's and the salvage logging interfered with the reforestation program during its first six years.

The Tillamook County timber harvest peak in the early 1950's generally coincides with a second harvest peak experienced in Clatsop and Columbia Counties in the early 1940's. The first harvest peak for these counties occurred in 1929 at the time Tillamook County experienced a relatively low harvest rate.

After the disastrous fires during the 1930's to the 1950's, efforts were taken to reduce the potential for a future fire to spread between watersheds. By the 1960's, approximately 212 miles of snag-free corridors had been constructed primarily along ridge tops with the corridors up to a half mile wide in places (USDA, 1966). These corridors were planned as a means to divide future fires into compartments for more effective fire control. In addition, nearly 160 miles of roads were built for fire, reforestation and timber sale access. Ironically, at the same time that clear-cutting of these ridge top corridors was being done, resource managers were advocating the elimination of road building and logging in the steep-sloped headwater areas of streams (USDA, 1966).

By the 1960's the scattered clear-cut unit of approximately 40 acre size evolved as the method for harvesting. The smaller clear-cuts are bordered by green timber —which serve as a seed source for reforesting cut areas — and the amount of contiguous cut areas of highly flammable logging slash is reduced. This change in harvest practice may be partially responsible for the change in the county harvest trend starting in the late 1950's. Private forest owners tend to clear-cut even smaller parcels of their forest lands than larger industrial forest owners in part because they are less willing to accept the cost of reforestation which is required by the state (Lettman and McKay, 1994).

Concentrated timber harvesting was also prompted by natural events. The Columbus Day storm in 1962 resulted in extensive areas of blown down timber and spurred efforts to remove downed trees by 1964 in order to prevent a Douglas Fir beetle epidemic (USDA, 1966).

Dredging and Navigation Improvements

The first interventions in the Bay were done by the War Department in the mid-1890's (Harbert, 1972) to improve navigation conditions (Figure 23). Prior to interventions there were four main tidal channels through the six mile-long Bay. Three dikes and dredging were done to connect two of the tidal channels. This resulted in the eventual reduction of the number of natural channels to two main tidal channels, each wider and deeper than the original four. A secondary result of these early interventions was the shoaling of the western half of the Bay (Harbert, 1972).

Most of the historic dredging at the entrance channel to the Bay has been to remove littoral sands that are continually deposited in the entrance channel by wave action. The main navigation channel through the Bay itself was dredged regularly since the late 1800's up to the mid-1970's, with most dredge spoils disposed of at sea and some placed at the commercial area in Garibaldi (U.S. Army Corps of Engineers, 1975). Disposal of dredged sediments also occurred at various other areas along the Bay margins. Dredging for navigation requires designated locations for spoil disposal. However, dredging for emergency purposes — such as to alleviate flooding — apparently has had less regulation and resulted in dredge spoil disposal on the alluvial fan area near the mouths of the Wilson and Trask Rivers (U.S. Army Corps of Engineers, 1975).

The frequency of these emergency dredge spoil disposal operations and the extent of spoil disposal may have had an impact on floodplain morphology.

Dredged material has decreased in volume since the 1940's (Figure 24) and, as of 1966, a majority of the main entrance channel has been self-maintained by natural scouring action (U.S. Army Corps of Engineers, 1975). In 1974, the Corps of Engineers determined that dredging of the upper Bay channels was to be economically infeasible because of the probability that the channels would have to be dredged each year and dredging would not prevent tidal flooding (Gilkey, 1974). Conversely, in 1974, state environmental experts advocated dredging the upper Bay and rivers in order to restore marine life in these areas following the changes caused by the 1972 floods (Wick, 1972).

The earliest human intervention along the coast and within the littoral cell that includes the entrance to Tillamook Bay was the construction of the north jetty during the period 1914 to 1918. Since the time of the north jetty construction, it has required repair in 1921, 1933, 1956 and 1963 to 1964. The jetty was extended 300 feet to 5,700 feet in length from 1931 to 1933 (Harbert, 1972). The Corps of Engineers estimate the jetties will require major repairs every 15 and 35 years (U.S. Army Corps of Engineers, 1975). Construction of the south jetty occurred from 1969 to 1974 and has resulted in sand being trapped along the shoreline of the spit.

Woody Debris Removal

The transport of large woody debris down river systems during high flows and flood events is a natural process. Historically, this process has conflicted with navigation. Since the 1890's the U.S. Army Corps of Engineers has documented wood removal from channel areas that they were improving for navigational purposes. The General Land Office (GLO) survey notes wood in channel locations where they chose to stop meander work. This survey work was done before the 1861 floods that pulsed wood from many of the coastal watersheds into the estuaries and beaches of Oregon and Northern California.

Wood jams are documented throughout the Tillamook Bay river valleys and primarily on the Wilson River (Figure 25). Large and repetitive jams were experienced at "The Narrows" at river mile 16 on the Wilson. If the jams were not released by dynamite, fall and winter storm runoff would back up behind the logs until they broke free. Wood jams were also prevalent on the Trask River (Figure 26). Given these conditions, the natural occurring freshets were likely accentuated by wood jam breakups and downstream river reaches experienced more severe flood action and release of trapped sediments than would have occurred under natural conditions. With the construction of bridges in the valley, there have been more opportunities for wood debris to become trapped (Figure 27).

A detailed historic review of woody debris and wood jams in the Tillamook Estuary is provided in Section IV.

E. The Impacts of Settlement on The Landscape

For thousands of years, chronic and periodic catastrophic natural events have acted upon the Tillamook Bay region and affected the geomorphic evolution of the system of rivers, tidelands, estuarine waters, and coastal landforms. These natural events changed the dynamic equilibrium conditions of the ecosystem and resulted in a landscape the Native Americans and early settlers experienced. As the Native American population declined and the settlement population grew, human interventions in the ecosystem increased and began to impact the resiliency of the ecosystem to recover and sustain itself. Different processes in the ecosystem have responded to these disturbances in different ways. These impacts generally occurred in the upland watershed, along the rivers and floodplains, and within the estuary and along the coastal beaches.

The Watershed

Flooding and sediment transport has historically been significant in the Tillamook Bay watershed from the small streams tributary to the larger rivers. Corps reports from 1902 and 1907 state that "a considerable quantity of gravel, sand, and mud is annually deposited in the bay and channels by the tributary streams" (Gilkey, 1974). As described in Bulletin 74 of the Oregon Department of Geology and Mineral Industries, “Throughout the Tillamook drainage at the height of the [January 1972] flooding, many small creeks, some too small to be shown on a map, turned into rivers of flowing mud, rocks and wood debris.” In the early 1970's, primary flood problems in the upper reaches of the watershed are associated with streambank erosion and flash floods (State of Oregon Department of Geology and Mineral Industries, 1973).

Soil cover is minimal in the upper reaches of the Wilson River watershed due to heavy rainfall, steep slopes. A lack of vegetation is due to the forest fires in the 1930's (Figure 28) (State of Oregon Department of Geology and Mineral Industries, 1973). Flash flooding is a potential problem from tributaries to the Trask and Wilson Rivers because the channels are short — typically less than one mile in length — and steep and are cut in volcanic bedrock (State of Oregon Department of Geology and Mineral Industries, 1973). Flooding serves to undercut the toe of slopes and initiate land slides. Figure 29 shows an historic photograph of destroyed riparian corridor along the Wilson River.

Mass wasting into river channels is a major source of sediment to the estuary. Landslides and mudflows can occur naturally or induced by road cuts. The Tillamook Bay Taskforce Report 1978 analyzed the watershed of each of the major rivers as of 1978, as shown in Table 3.

Because of the character of watershed topography and its soils, infrequent but catastrophic mud flows such as the January 1965 event on the Wilson River can occur. This event dammed the River to a height of 60 feet. There is evidence that these flows occurred naturally during extremely wet years (State of Oregon Department of Geology and Mineral Industries, 1972). All along the Trask River drainage slides are present at various stages of development.

Table 3
Summary of Man-Caused and Natural Landslide Findings from the 1978 Erosion and Sediment Study

River	Number of Man-Caused Landslides	Number of Natural Landslides	Road Miles (1975)
Miami	526	84	336
Kilchis	828	28	692
Wilson	1,870	86	2,262
Trask	1,092	30	2,168
Tillamook	124	12	630

The tributary streams in the area are characterized by short, steep slopes with variable soil and vegetation cover. Natural and human-induced conditions can change sediment and flow input to the mainstem rivers and the Bay. Where soil is thick on steep slopes, these areas are susceptible to mudflows. Mudflows tend to originate in channels of short length and recur along the same channels and are aggravated by heavy rains (State of Oregon Department of Geology and Mineral Industries, 1973).

During the January 1990 flood, the heavy rains caused landslides, canyon blowouts and debris dams in tributary streams beyond the extent of the valley floodplains (Federal Emergency Management Agency, *et al*., 1990). The storm was reported to have damaged the system of forest roads and county roads and destroyed road culverts, drainage systems and road shoulders. The 1990 storm caused $1.3 million (1990 dollars) in damages to local railroad facilities from washouts, destroyed trestles, and undermined track beds.

Stream crossings in the upper forested portions of the river watersheds can represent points of erosion and locations for accelerated sedimentation. Numerous railroad and logging road crossings of ephemeral and perennial stream channels exist in the Bay watersheds. The National Estuary Project Scientific/Technical Advisory Committee (LaFrance, 1995) Issue Form on Sedimentation identified road and culvert failures as one of the most significant contributors to the mass wasting processes in the Bay watersheds.

In 1880, Tillamook County and areas around the Bay were practically a wilderness and few roads existed (Dicken, 1978). Beginning in 1923, development in the county was on an upswing and more roads were needed to allow tourists to reach the resorts on the coast. The efforts of the Civilian Conservation Corps (CCC) resulted in the construction of many miles of truck trails, the cutting and burning of miles of road right-of-way, and the installation of culverts and ditching (Dicken, 1978).

An interagency report on the January 1990 flooding in Tillamook County acknowledged that a majority of the landslides occurring during the storm originated from roads built as timber salvage roads during the period 1940 to 1960 (Federal Emergency Management Agency, *et al*., 1990). The salvage logging roads were hastily constructed and used under-sized culverts, log culverts, had poor alignments on the natural grade and had excessive side cast material susceptible to erosion. This flood prompted a recommendation to obtain grant funding to study the forest road system and determine which roads should be rebuilt or abandoned and which drainage structures should be replaced or repaired (Federal Emergency Management Agency, *et al*., 1990).

The significance and potential for sedimentation from stream crossing becomes more apparent when the locations of these crossings are viewed at a watershed-scale over time. Figure 30 shows the progression of railroad and road stream crossings within the Tillamook Bay watershed from the 1930's to the 1980's. The historic spread of the population in the valley areas and locations of interventions in the upland portions of the watershed becomes evident. Stream crossing impacts originated from the estuary population centers and spread along the major rivers, especially the Wilson River. Following the fires and reforestation efforts, road building increased the number and location of stream crossings in the upland portions of the watershed. Even since the 1950's a significant number of crossings have been made and have resulted in a nearly uniform coverage of stream crossings throughout the Bay watersheds.

One impact of past watershed burns has been to change the hydrologic response to runoff — or the ability of the surface soils to retard runoff — of forested areas. Burned areas, and especially areas of repetitive burns, show a degraded ability to store moisture in surface soils. The 1978 erosion and sedimentation study classified the Tillamook River watershed as having the best hydrologic response — land having deep soils with high infiltration rates capable of retarding runoff — with the Trask, Miami, and Wilson watersheds ranked in descending order and the Kilchis watershed having the poorest hydrologic response —land having shallow soils with slow infiltration rates when wetted. Accelerated runoff from burned areas has the potential for increasing soil erosion and sedimentation into rivers. Erosion and sedimentation can be especially significant from upper reaches of forested watersheds due to steep channel banks, thin soils and greater rainfall amounts with elevation gain.

One of the largest reforestation efforts in the country was begun in 1949 (Oregon Department of Forestry, 1993) in the burn areas and is acknowledged as a management measure successfully improving hydrologic response in burned areas. Reforestation after the last major forest fire in 1951 was not completed until 1970 (Federal Emergency Management Agency, *et al*., 1990) and during that time periods of heavy rainfall have occurred causing large quantities of runoff and erosion. There are areas in the estuary watershed that have been burned repetitively (U.S. Dept. of Agriculture, 1966). The potential for erosion and landsliding can be put into perspective by viewing the repetitively burned areas in the context of the precipitation potential (Figure 31).

A conceptual indication of how sediment delivery rates from the watershed might have changed in response to watershed disturbance and reforestation is shown in Figure 32 (Tillamook Bay Task Force, 1978).

The Rivers and Floodplains

Watershed impacts have altered natural weathering and erosion processes in the upland areas and temporarily changed the sediment delivery patterns to the rivers and floodplains. Human management of the lowland rivers to control subsequent downstream impacts has further changed the fragile dynamic equilibrium conditions of the river systems. Since the time of settlement, the human perception of the value and function of the river system has changed, partially through observation of how rivers have responded to increasing human interventions.

An account of life along the Bay in 1919 mentions the trip from Idaville to Tillamook was often difficult in the winter because the road was under water (Strite, 1971). Construction of the railroad near Idaville in 1919 was done such that the roadbed was elevated three feet or more above the natural ground to prevent the track from being flooded (Strite, 1971). This early recognition of natural flood processes served to guide the early settlement of the human population and generally kept people out of harms way or at least minimized encroachment into floodplain areas. The valley landscape rapidly changed to accommodate more farm area, buildings and roads — driven primarily by increasing demand for agricultural and dairy resources requiring floodplain lands and aggregate resources extracted from the rivers directly — and marked the beginning of significant encroachments into these sensitive areas. Flooding from the Wilson River is shown affecting traffic in an historical photograph in Figure 33.

As the human population encroached into floodplain areas, natural and human-induced catastrophic events continued to occur in the uplands. The major forest fires that occurred during the 1930's to 1950's, and especially the areas of repetitive burns, disrupted the infiltration and water storage capacity of the upland areas. The loss of this natural flood attenuation mechanism, coupled with the existing steep slopes and impermeable ground conditions, increased the frequency and quantity of runoff and sediment delivery from heavy rainfall events. Landslides from natural slope failures or induced by road and culvert construction introduced additional pulses of sediment to the riverine systems.

Most Tillamook Bay rivers reach flood stage or higher each winter (Federal Emergency Management Agency, 1978). The annual river flood levels can be increased when coastal flooding occurs simultaneously and forces flood waters higher with high tides, storm surge and wave action. It has been noted that flood elevations near the City of Tillamook are very similar for all flood frequencies (Levesque, 1980). This condition is attributed to the wide floodplain and the overriding influence of the Bay water elevations at the time of river flooding.

In order to protect the increasing value of property and structures that were developing in floodplain areas, interventions were increased to control flooding and sediment deposition in the valley. Dredging, woody debris removal, levees and diking, were done to protect economic assets now located in floodplains. These responses to control flooding have resulted in a reduction of the natural complexity of river channels and the separation of the river from its floodplain. Ironically, the loss of natural floodplain functions has, in turn, impacted natural resources with economic value, such as the fish and shell fish industries, that attracted commercial and residential development in the floodplain in the first place.

Dredging and woody debris removal made navigation easier and the removal of riparian vegetation and construction of levees and dikes maximized the area of land available for agriculture. These controls artificially fixed an equilibrium condition in the valley to satisfy the short-term needs for maintaining and growing the commerce and economy of the local area — but sacrificed the long-term sustenance of the valley landscape and biological resources of the valley and estuary. Salmon production and carrying capacity of the rivers was reduced through the loss of river channel complexity in shape and substrate, for spawning and rearing, and the loss of woody debris, for cover and food.

The disconnection of rivers from floodplains by levees and diking presents a more dramatic example of an impact to the ever changing equilibrium conditions of the rivers and floodplains. The construction of levees and dikes reduces the frequency of lower elevation flooding over floodplain lands. In turn, this reduces sediment and organic nutrient deposition. The lack of flood water overflow, coupled with long-term precipitation trends, may reduce the frequency of seasonal recharge to alluvial aquifers and can lead to changes in plant and wildlife habitat because of changing soil moisture availability.

The long-term maintenance problems associated with levees may be put in perspective by viewing the historic changes river channels have undergone this century alone. Plate 4 presents a mapped compilation of river planform — or channel surface shape — changes between the 1930's and 1980's.

The dynamic nature of these river systems becomes more apparent when viewed in an historical context.

One direct impact from river channel changes is streambank erosion. A 1973 report titled "Streambank Erosion in Oregon" provides a general assessment of eroded streambank length by county and stream (State Soil and Water Conservation Commission, 1973). The 1978 Tillamook Bay Drainage Basin Erosion and Sediment Study (Tillamook Bay Task Force, 1978) was the definitive study on erosion in the Bay watershed. In this study, streambank erosion and sheet and rill erosion of agricultural lands were identified as the two mechanisms for introducing sediments to the lower elevation meandering reaches of the rivers. Streambank erosion was the more predominant of the two types. Table 4 provides a summary of detailed tabular data on streambank erosion presented in the report. Mapping of critical streambank zones and stream stability was also prepared.

Table 4
Summary of Agricultural Lands Streambank Erosion
Findings from the 1978 Erosion ands Sediment Study

River	Total Length of Streambank Evaluated (feet)	Percent of Total Streambank Rip Rapped	Percent of Total Streambank termed Critical Erosion Area
Miami	53,833	25	1.4
Kilchis	81,793	49	1.4
Wilson	95,040	25	1.2
Trask	111,288	19	1.5
Tillamook	166,138	1.7	0.5

Source: Tillamook Bay Task Force, 1978, Tables VII-3 to VII-7.

Streambank erosion is a natural process in any fluvial system. It is difficult to differentiate between natural occurrences of this type of erosion from those induced by human interventions. Past sediment studies have not made this distinction as has been done for sedimentation from landslides — which have more distinct natural and human causes.

The existing levees and dikes have been ineffective in protecting land during major floods since the 1960's because the structural integrity and elevation may not be adequate to withstand flood forces. Inspections of levees during the 1950's revealed these structures provided questionable protection because they were eroded by rain or trampled by cattle (Thomas J. Murray & Associates, 1960). Brush coverage, muskrat and beaver burrows also have reduced the integrity of these flood control measures. The effectiveness of these measures is uncertain at lower frequency floods — such as floods that occur every year or every other year. Past flood insurance studies indicate the 100-year floodplain in the vicinity of the river deltas is about 9.0 feet, NGVD (National Geodetic Vertical Datum of 1929) in elevation (Federal Emergency Management Agency, 1978) and this flood condition overtops most of the levees and dikes.

A summary of historic coastal and riverine significant flood events in the Tillamook Bay area is presented in Figure 34. In this figure, significant flooding is noted as flooding of enough significance to warrant past newspaper coverage or documentation in flood insurance studies. Given this definition, significant flooding is seen to be increasing in frequency over time and has increased dramatically since the early 1960's. The increasing population growth in the county has resulted in increasing development in the floodplains over time. With this development trend, the significance of floods — in terms of damage to property and structures — has likely increased because more property is exposed to flood waters within the natural floodplain areas.

The infrequent nature of flooding and the transient nature of people continues to result in a public perception that floods are few and far between. In the Tillamook area, more frequent floods of large magnitude have changed the statistical perception of flood severity over time. For example, the December 22, 1964 flood on the Trask River was estimated as a flood event having a chance of occurring once in a 90 year period in the 1978 Tillamook County flood insurance study (Federal Emergency Management Agency, 1978). Currently, that same flood would be assigned a flood “return period” of approximately 25 years (Figure 35) because the intervening years of frequent flooding have relegated that historic flood to a lesser magnitude.

Increased construction of buildings and public infrastructure in floodplains may also serve to exacerbate erosion problems from flooding. Flood water movement during past floods is highly variable and does not necessarily follow a direct downstream direction — especially in the vicinity of the confluence of the four rivers in the south Bay area. During the January 1972 floods, rotational flow was observed in the vicinity of Hall, Dougherty and Hoquarten Sloughs (State of Oregon Department of Geology and Mineral Industries, 1972). These variable flows are caused by natural phenomena such as tides and natural impoundments, but are also effected by human interventions in the valley such as road fill obstructions, buildings, flow concentration through culverts and bridge openings, and diking. The majority of flood damages occur to agricultural buildings, livestock and pastures (Federal Emergency Management Agency, *et al*., 1990). Construction of structures in floodplains can be designed so that flood damage is minimized, but one effect of flood proofing — by earth fill, levees, or walls — will be to redirect flood water, increasing the variability of flood flows and possibilities for concentrated water velocities and subsequent erosion.

The Estuary

The effects of watershed, river, and floodplain landscape changes have been transferred downstream to the estuary through increased sediment delivery and indirect human and animal waste discharges. The resiliency of this portion of the ecosystem to these chronic disturbances is a key concern for resource management.

The physical resiliency of the estuary can be assessed to some degree by observing intertidal changes to the historic estuary shoreline and subtidal changes to the estuary morphometry. Intertidal changes are readily observed from historic mapping of the estuary shoreline and can provide an account of the ecosystem response to disturbances. More subtle changes occur within the estuary as littoral sands that are suspended by wave action move into the estuary on the flood tides and are deposited as a flood tide delta inside the entrance channel. Over time, these flood tide deposits reach a dynamic equilibrium between sedimentation and scouring on the ebb tide. This equilibrium has been significantly altered in recent historic times by human intervention through the construction of the jetties and the breaching of the Bayocean Peninsula by natural forces induced by the jetty construction.

Plate 4 provides a comparison of the Tillamook Bay estuary and nearby coastal shoreline conditions for the years 1867, 1939, 1953 and 1980. It shows the stable coastal headland of Cape Meares and the varying shorelines of Bayocean Peninsula and the Bay margins. In general, the pennisula has experienced the most observable historic changes both from human interventions and natural responses. The open coast shoreline along the pennisula has receded landward since the 1800's, to such an extent that the 1980's coastal shoreline is now aligned with the 1800's Bay shoreline.

A detailed evaluation of beach changes after the construction of the north jetty revealed that sand deposition occurred along both the north and south sides of the jetty. The northern shoreline advancement is apparent from historic air photos, but the shoal south of the jetty is at a lower, submerged elevation and not as apparent. It has been concluded that construction of the north jetty actually impeded navigation and is one of the reasons for the depression of the fishing industry out of Tillamook Bay (Terich and Komar, 1974). About 250 acres of sand had accreted behind the north jetty as of 1972 (Harbert, 1972).

Shoreline erosion rates along the Bayocean Spit appeared to coincide with the construction of the north jetty in 1918 (Harbert, 1972). Shoreline losses were recorded in the 1920's and 1930's, with accounts of 6 feet of shoreline being lost per year (Harbert, 1972). Aerial photo interpretation between 1939 and 1944 indicated erosion averaged 16 feet per year. In 1932, waves first breached the spit. A comparison of hydrographic surveys from 1866-67, 1885-91, and 1926-27, and 1939 showed significant erosion had occurred at the 60 foot offshore contour and extensive accretion has occurred between the 60 and 180 foot contours (Harbert, 1972). The most accelerated erosion of the spit appeared to coincide after the repair and 300 foot extension of the north jetty in 1932-33 (Terich and Komar, 1974).

The historic breach of the spit occurred in 1952 and was caused by severe storm waves combined with higher than ordinary tides (Figure 36). Without the protection of the spit, the Bay experienced abnormally high tidal levels and tidal surges. These conditions increased tidal ranges and wave action in the Bay and presented significant erosion problems for the river levees. Sand introduced to the Bay through the breach covered over a third of the 3,000 acres of oyster bed tidelands. The control of tidal flow switched to the breach opening and, with the reduction of scouring tidal currents at the jettied entrance, the original Bay entrance was threatened with potential closure from accreting sands. Immediately after the closure of the breach in 1956, local fishermen reported a renewed tidal action within the Bay and subsequent erosion of the accumulated sand bars (Terich and Komar, 1974).

The repair of the breach in the peninsula in 1956 resulted in a dramatic change to the Bay shoreline: fill encroached into the Bay approximately 2.5 million square yards (Levesque, 1980). Table 5 provides a summary of significant shoreline fills between 1867 and 1977 and shows that the Bayocean peninsula fill represents approximately 53 percent of the fill into the Bay during this time period. Kincheloe Point has been artificially extended to the northwest with the construction of the south jetty by 1974. The Bay shoreline of the point has receded westward, increasing the area of Crab Harbor. Only the portion of the peninsula just north of the former community of Bayocean has remained relatively unchanged possibly because of more resistant underlying geology. The area of Garibaldi represents the next largest fill into the Bay. Approximately 10 percent of the shoreline fill between 1867 and 1977 is associated with the construction of the town and commercial areas.

The Bay shoreline along the southwest side of the Bay, between Pitcher Point and Dick Point, and along the east side of the Bay, between Miami Cove and Kilchis Point, have been relatively more stable over time. The variability in the mapped shorelines may be partially attributed to the different map scales the shorelines were taken from, the tidal elevations at the time of the aerial photography and the level of accuracy of the original surveys. Acknowledging these potential

Table 5
Tillamook Estuary
Significant Shoreline Fills, 1867-1977

Location	YD^2 Area (million)	% of Fills	% of Estuary Area
River Deltas	1.5	33	3.5
Miami	0.1	2	0.2
Kilchis-Wilson	0.9	20	2.1
Trask-Tillamook	0.5	11	1.2
Bayocean Spit	2.6	57	6.1
Breach + Dike	2.5	53	5.7
Kincheloe Pt.	0.2	4	0.4
Garibaldi	0.5	10	1.1
TOTAL	**4.6**	**100**	**(10.7)** **11**

Source: Levesque, 1980

sources of error, general observations can still be made.

The shoreline between Pitcher Point and Dick Point appears to have been stable over time. Some of the river confluence embayments showing on the 1950's mapping have been filled evening out the 1980's shoreline. Along the east side of the Bay, the locations of Hobsonville, Goose and Kilchis Points are relatively stable over time. The shoreline between Goose and Kilchis Points has extended into the Bay, perhaps from sediments from the creeks tributary to this portion of the shoreline. Between Goose Point and the piers at Bay City to the north, there is a noticeable historical trend of shoreline recession with the greatest change occurring between the 1930's and 1950's mapping. During the period the Bayocean breach was open — from 1952 to 1956 — there were observations of increased wave action in the Bay. Perhaps one effect of the breach was to accelerate shoreline erosion along the east side of the Bay between Goose Point and the piers at Bay City to the north from wave action. The shoreline from the 1980's is in between the 1930's and 1950's shoreline and may represent some filling and a stabilization efforts associated with the open lagoon and residential construction.

The most dramatic encroachment has occurred in the southern end of the Bay where the river deltas of the Kilchis, Wilson, Trask and Tillamook Rivers meet. Shoreline changes indicate a general progradation of the deltas into the Bay, with the exception of the shoreline from the 1950's mapping. Again, the breach of the peninsula in the early 1950's may have introduced a more severe wave climate into the normally sheltered waters of the Bay and caused a change to the equilibrium conditions. The 1950's shoreline seems to align with the 1860's shoreline and may indicate the extent of less erodible sediments. Therefore, the period from the early 1950's to the 1980's resulted in delta growth that generally regained the shoreline conditions of the early 1930's and then continued into the Bay, up to 3,000 feet beyond the 1930's shoreline.

The delta region of the Miami has generally been stable through the 1950's with a significant amount of progradation into the Bay occurring between the 1950's and 1980's mapping. The delta growth in this area is undoubtably related to an increased sediment load delivered from the river, but may also be attributed to a wave sheltering effect the filled area at Garibaldi provides. Wave action may be less pronounced and less capable of resuspending delta sediments as they collect in this vicinity.

Five waste water treatment plants (WWTPs) currently discharge treated effluent into the estuary. The Bay City and Garibaldi WWTPs discharge directly to the estuary and the other plants discharge to the Trask and Wilson Rivers within the tidally-influenced reaches of the rivers. Table 6 provides a summary of the plants , the date of construction, the current treatment system and the current installed capacity — the maximum rate of sewerage flow that can be treated by the plant — and the plant discharge location. A comprehensive water and sewerage plan was prepared for Tillamook County in 1969 and is currently the latest comprehensive plan for the region.

Table 6
Historic Summary of Tillamook Bay Waste Water Treatment Plant Development[2]

Waste Water Treatment Plant	Collection/ Treatment System History	Current Installed Capacity (mgd)	Average Annual Flow/Peak Flow (mgd)	Current Problems
City of Garibaldi	1973—activated sludge/sand filtration; 1946—collection system.	0.5	0.4/0.9	Infiltration and inflow in winter; over-capacity flows are bypassed from treatment.
Tillamook County Creamery Association	1995—2 stage activated sludge; 1969—activated sludge package plant; 1948—separator basin with trickling filter.	0.5	0.25	None—controlled waste flows do not have variable inflows like municipal systems.
City of Bay City	1996--- Sequential Batch Reactor (SBR); 1972— two cell waste stabilization lagoon; 1972—collection system.	0.3	0.24/1.45	Limited— Peak flows in excess of installed capacity are stored in original lagoons.
City of Tillamook	1980—rotating biological contactor; 1969—trickling filter, secondary clarifier, disinfection; 1950—collection system.	2.0	0.6 summer/ 4.5 winter	Infiltration and inflow in winter; motels can overload system in summer months; over-capacity flows go through system at reduced level of treatment.
Port of Tillamook Bay	1968—Lagoon systems; 1942—Collection system.	0.56	0.77/1.7 (no flow in summer)	Collection system built during WWII. Infiltration/inflow extreme in winter. New septic tank effluent pressure system to be constructed in 1997.

[2]Information obtained from current treatment plant managers

The municipalities along Tillamook Bay do not have comprehensive storm water drainage plans. Storm drainage systems have typically evolved along with the sporadic residential and commercial development in these areas. In areas outside the urban centers but within the Urban Growth Boundary, small piped drainage systems have been constructed for residential developments and discharge to nearby natural drainage features.

F. The Environmental Response

The Salmon Fishery

Over time, the native populations of steelhead, salmon and cutthroat trout have adapted to the naturally changing habitat conditions in the coastal river systems. As Euro-American settlement was established within the Bay ecosystem it prospered, in part because of the fishery resource. Continued population led to interventions into riparian areas and began to reduce the extent of freshwater habitat needed to sustain subsequent generations of the fishery. Management reactions to the declining fishery led to the introduction of hatchery fish and changes in the harvest methods and locations. Mortality effects during the saltwater portion of the anadromous fish life cycles remains largely unknown.

The coho salmon has been viewed as the indicator species because it has been historically abundant in the estuary and its decline has been relatively well documented through catch and escapement records. The number of naturally spawning coho salmon in Oregon has been decreasing since records were first kept in the late 1800's (Mullen, 1981) and their demise parallels the reduction in the capacity of coastal streams to support salmonids during their freshwater life cycle stages (Lawson, 1993). Prior to 1960 in Oregon, coho landing data was more representative of wild coho salmon production because hatchery production of the fish increased significantly after that year (Mullen, 1981). For these reasons a report by ODFW in the early 1980's stresses that “landings and events [of coho] prior to 1960 [should be used] as benchmarks against which future management decisions could be measured” (Mullen, 1981).

The early 1960's represent a transition point between trends in wild and hatchery coho stocks. Tillamook Bay remained open for commercial fishing until 1961 (Mullen, 1981). Research by ODFW in the early 1980's noted a relationship between the decreasing trends in Oregon salmon escapement and increasing hatchery releases and decreasing coastal upwelling (McGie, 1981). By noting that Oregon coastal coho stocks had experienced declines in streams with and without hatcheries, it was theorized that natural mortality had increased in the ocean ecosystem. The turbulent characteristics of the coastal zone may cause prolonged periods of reduced food availability for coho smolts along certain portions of the coast, increasing mortality. The warmer temperature trends at Tillamook may have a relation to the future strength of coho runs because the ocean temperatures, coupled with upwelling, determine the food source availability for the fish. The reduction in the upwelling of cold water associated with the warmer water El Nino events reduces the nutrients available for fish, because the conversely, warmer currents from the equator are less nutrient rich and bring other fish species, such as mackerel, which feed on coho.

Coho are on a three year life cycle, with about one and a half years spent in freshwater and the remaining period of time spent in the ocean. They are a schooling fish and the appearance of many fish at one location can be misleading as to the overall strength of the population along the coast. Peak harvest years in 1924 and 1935 may be due to the return of a strong brood year class and favorable conditions in the Bay. The 1991 peak in the recreational harvest resulted from the coho being “pushed” ashore due to unfavorable ocean conditions coinciding with the closure of ocean fishing of coho. The cyclical nature of the ocean environment for salmon production when coupled with the quality of freshwater habitat may actually mask the steady decline of freshwater habitat (Lawson, 1993) (Figure [37]).

Wetlands

It is clear that there have been substantial changes to riparian and floodplain wetland ecosystems due to levees and land drainage. Loss of riparian woodlands along river banks has probably increased bank erosion, reduced channel complexity and woody debris, reduced insect food supply and reduced shading — all of which can have substantial impacts on anadramous fish. The loss of almost all floodplain wetlands has eliminated major channel rearing habitat as well as disconnecting a source of nutrients and food for the estuarine food web.

Tidally influenced freshwater and brackish wetlands have been reduced in extent and connectivity, with most of the existing tidal marshes having been recently created over the last 50 years and probably lacking the complexity and diversity of habitat that the older marshes provided. Figure 38 shows the extent of hydric soil (indicative of former wetlands) that have now been reclaimed for agriculture in the southern portion of the Tillamook Bay.

Shellfish

Shellfish have been a significant historic resource of the Bay. The Native Americans relied on crabs and clams to augment fish and game for food. Native clams spawned an early industry following Euro-American settlement. Today, Tillamook Bay has become the largest contributor to the state's commercial clam harvest. With the decline of the salmon resource of the Bay, the stability and apparent increase in production of another biological resource from the ecosystem is significant.

The sustainablility of the shellfish resource is directly dependant on the water quality and consistency of the estuary sediments and tidal currents necessary for each shellfish species to survive. The generally immobile nature of the mollusks — coupled with the relatively minor amount of direct and permanent human intervention into the estuary itself (limited to piledikes where they exist) — may have only temporarily disturbed these shellfish at the times of the interventions. Daily and seasonal natural disturbances within the subtidal portion of the estuary, such as tidal current, tend to be more neutral than in the more dynamic river system and these changes are tolerable to these organisms. Significant sediment pulses from floods and water quality degradation are the primary external influences of management concern.

Damages from the floods of January 1972 were documented and included mention of impacts to the Tillamook Bay oyster industry (U.S. Army Corps of Engineers, 1972). It was determined that the flood would cause losses for several years because re-stabilization of the substrate necessary for culturing oysters can take up to five years following a major flood. Similarly ,damages to the oyster industry in the Bay occurred from floods in 1965 and 1952. The recurring natural flood events have instilled in the Bay oyster growers a sense of anxiety in risking capital in large quantities of spat — or first year oysters — and this may be one of the reasons the oyster industry in Tillamook Bay has not significantly increased over the years. One of the reasons Tillamook Bay oysters are vulnerable to sediments from floods is because they are cultured on the bottom of the Bay, as opposed to being cultured in suspended baskets (U.S. Army Corps of Engineers, 1972). The shallow depths of the Bay apparently prohibits the use of baskets in this manner.

Historically, water quality degradation to the Bay has been primarily characterized by bacterial contamination. Although this form of environmental pollution is detrimental to the resources of the Bay, the effects of the contamination are generally short-lived. The physical and chemical processes in the estuarine ecosystem are dynamic enough so as to limit the duration of this disturbance. The shellfish are able to recover also from the effects of bacterial contamination.

Management techniques have evolved for temporarily closing the shellfish harvest in the event of potential water quality degradation as inferred by river flooding into the Bay. These techniques are based on our best guess at the duration of the water quality disturbance. With a growing human population and urban development in the Bay ecosystem, increased water quality degradation from toxic pollutants may complicate present management techniques because these pollutants are more persistent in the environment. The resiliency of the estuarine ecosystem to water pollution would be lowered with the increased introduction of non-degrading pollutants and the present short duration ecosystem disturbance may evolve to a sustained management problem. At issue is the build up of toxins in the Bay sediments — the growth medium for shellfish — and the bioaccumulation of these toxins in the food chain.

IV. History of Coarse Woody Debris in the Tillamook Estuary Area[3]

A. Background on Ecological Functions of Coarse Wood in Aquatic Ecosystems

The importance of coarse woody debris in streams, rivers, and estuaries has become more evident as we have become more knowledgeable about the many and diverse functions of wood in these systems. In streams and rivers, these functions include protective cover for aquatic organisms and the creation of in-channel pools and slackwater eddies. The structural value of wood extends to high flow channels and floodplain lands that are only periodically inundated where, for example, uprooted trees can create backwater refuge areas for fish. In-channel wood contributes extensively towards the retention of gravels, sediment, leaves, and other nutrients.

Large, downed wood is one of the components that nurtures and sustains communities of fish and other organisms within estuaries, as well. In tidally-influenced sections of rivers, sloughs, and bays, many of the functions of wood are similar to streams and rivers. Large wood creates habitat and cover for estuarine organisms. Cover is especially important within an estuary where, during low tide, fish and other organisms are confined to the tighter quarters of the remaining watered areas in the channels of the Bay.

On tidal flats, in marsh areas, and in the estuary water, drift wood, snags, and human wood structures like pilings are used by various bird species as sites for perching, foraging, and feeding (Bayer, 1978, 1983). The drift wood along marsh boundaries within the Bay are used as nurse logs for Sitka spruce seedlings (Johannessen, 1961; Stembridge, 1979). In marsh areas, downed wood creates microhabitat that captures seeds and protects young plants. When the wood is dragged over a marsh surface during a storm, it can create microhabitat depressions in the soil.

What is especially interesting is that in salt-influenced waters of an estuary, wood-boring organisms chew submerged wood into sawdust. A significant proportion of this wood material consumed by the wooder borers enters the estuarine system, mostly as undigested material in the feces, to be an accessible nutrient source to the larger community of organisms (Gonar, 1986; Gonar et. al., 1988; Maser, C. and J.R. Sedell, 1994).

There are two groups of wood-boring organisms in the Pacific Northwest. One is an isopod crustacean, called a gribble. The other is a bivalve mollusc, called a shipworm (Gonar et. al., 1988). There are both native and introduced species of wood-borers in the Northwest. The U.S. Army Corps of Engineers (1888) referred to the introduced shipworm in the Tillamook Bay in several annual reports, "the teredo are very destructive in the Bay."

Because of wood-boring organisms, the residency time of wood in the salt-water portion of estuaries is much shorter than in streams or rivers, where logs remain in the channel for a fairly long time. Likewise, as wood is consumed in the salt-water zone, a replacement wood supply is important to an estuary. This replacement supply can come from the estuary watershed, from lands immediately around the Bay, or delivered by the ocean from other areas.

The ecological linkages through wood from the watershed to the larger landscape do not end at the estuary. Large woody debris can enter the ocean environment, where it plays multiple ecological roles on beaches, tidal pools, floating on the sea, or sinking to the ocean floor. For example, when piles of large woody debris reach the ocean floor, they serve as habitat and the beginning of a food web for a community of organisms (Turner, 1973, 1977). At least forty-one species have been identified in these communities, including sponges, sea anemones, amphopods, decopods, gastropods, and non-boring bivalves (Turner, 1973).

[3] Patricia A. Benner, Principal Author.

Wood stabilizes sandy beaches and provides protected areas where plants can germinate. During storm events, woody debris batters rocky intertidal shorelines and is thought, through this disturbance, to enhance species diversity of intertidal communities (Terich and Milne, 1977; Stembridge, 1979). So, the linkages between a watershed and the larger landscape does not necessarily end at the Bay.

The wildlife and fisheries observations — and research regarding wood in Pacific Northwest estuaries — gives strong evidence that coarse woody debris plays a significant role in these ecosystems. The following section (Section B) characterizes the historical amounts of coarse woody debris that were most likely present in the Tillamook estuary prior to Bay and watershed modifications. Though these historical data are but one "snapshot" spanning about one-half a century, these data can provide a framework for discussion of wood as a significant structural component and organic carbon source for the estuary.

B. Historical Accounts of Estuary Large Woody Debris

Within the northern Oregon coast range mountains and along the Oregon coastline in the 1800's, there were extensive amounts and sources of coarse wood for estuaries (Benner and Sedell, 1987). This wood most likely came from a number of sources, including the watershed hills and mountains, from lands immediately around the Bay and along the tidal portions of the rivers, or delivered from other areas by the ocean.

The historical record contains data and descriptions that help to characterize the presence of wood in Tillamook Bay and its tidally-influenced river reaches and sloughs. This work utilized two especially helpful sources of information. The first was the General Land Office's original township survey field notes, that provided early information on wood jams in the estuary, and documented wood sources. Data from the U.S. Army Corps of Engineers Annual Reports to Congress, reviewed by Benner (1990), were contributed to this work. Through these historical information sources and supporting material, it can be surmised that large woody debris was present as a significant ecological component of the Tillamook Estuary.

The First Land Surveys

The original government survey work contracted by the General Land Office provides information on wood, including the presence of wood in the Tillamook Bay area and documentation of the sources of wood from river and tributary corridors in the lower and upper watershed.

The first land surveys of the Tillamook Bay area were completed in two stages. The initial survey work was done in the 1850's, surveying lands neighboring the Bay. The areas surveyed were the level and gentle gradient lands that were most likely to be settled. At a later date, mostly in the 1870's and 1880's, the rough, mountainous areas were surveyed. During the 1850's survey work these lands were not subdivided because they were considered "unfit for settlement."

As mentioned earlier, coarse woody debris in a bay is of special value as cover during low tide for fish and other organisms inhabiting the Bay waters, when the watered area is limited to the deeper channels. The extent of the watered area in the Tillamook Bay apparently widely varied between high and low tides, as illustrated in a number of historical accounts.

After walking the north boundary of Township 1 South Range 10 West in September, 1856, Surveyor Snowden described the Bay.

> "The Tillamook Bay extends about 4 or 5 miles north and south and about 3 to 4 east & west. — It is shallow and when the tide is out leaves the mud bare on about two thirds of its surface...The tide rises about 8 feet." (N. bound. of T1S R10W, Surveyor Snowden, Sept., 1856, p. 8).

After completing township survey work of the valley lands of this township, Snowden further wrote,

> "Tillamook Bay is generally very shallow, tho' there is said to be good channels for small vessels up the

> Hoquarten Slough & Tillamook River." (T1S R10W, Surveyor Snowden, at end of walking interiors, ended October 30, 1857, pp.116-17)

The U.S. Army Corps of Engineers gave similar descriptions of the Tillamook Bay in 1887 and 1889.

> "The general depth of water is small and there are many flats bare at low water. Several channels extend to the head of the bay, but they are somewhat tortuous and have only a small depth of water. The flats and channels have both changed slightly in position since the Coast Survey examination of 1867, the only survey known to have been made of the bay and is entrance." (Report of the Chief of Engineers, 1887-88, 2nd Session, 50th Congress; Benner, 1990).

> "The bay at low tide consists of three channels running through vast sand and mud flats. These channels are of fair depth near the entrance, but gradually shoal up, giving depths of only 1 or 2 feet, near the head of the bay."(Report of the Chief of Engineers, 1888-89, 1st Session, 51st Congress, p.357) (Benner, 1990)

Though Captain Gray reported that his ship entered Tillamook Bay in 1788, several weeks earlier Englishman John Meares wrote in his journal that his boat did not enter, and referred to the entrance bar and Bay as "Quicksand Bar" and "Quicksand Bay" (Nokes, 1991). Tidal flats exposed during lower tide may have spawned these descriptive names.

Historical Accounts of Estuary Woody Debris

In the 1850's, surveyors under contract with the General Land Office meandered the Tillamook Bay shoreline and a short distance up the major channels connected to the Bay. Meander survey work involved following a shoreline or river bank, and noting each change of direction. The surveyors noted larger wood jams in the tidal reaches of major channels as part of the meander work. The approximate locations of the wood jams mentioned in the 1850's meander survey are noted on the map in Figure 25.

The wood jams seemed to have often been located near the head of tide. For example, along the Kilchis River slough the surveyor walked,

> "...to a point where the [Kilchis] river becomes shallow and obstructed by drift [and] it was thought useless to meander it any further up..." (General Land Office, 1857).

The surveyor's 1857 account of the last five miles of the Tillamook described the river as containing large wood. It was reported that,

> "...the Tillamook River is navigable from section 7 to the ocean — and would be so for small steamboats if cleared of drift." (General Land Office, 1857).

On the Wilson River, the field notes reported the length of two wood jams, probably because the meander work was continued past the jams, on upstream. These major jams were each about 800 feet long (General Land Office, 1857). One was described as "drift in river," and at the other "river obstructed by drift." Table 1 lists the descriptions of the drift jams at each of the sites noted on the map in Figure 25.

Farnell (1980) also gave an early account of wood jams in the Wilson River, as part of his navigation studies. He researched log drives on the Wilson, and reported that in 1889 the Wilson River was leased for the floating of logs, timber, and lumber from river mile 2 to 30 (Farnell, 1980). The lessee, W. I. Runyon,

> "...was not able to run logs in the river '[because of driftwood dams].' He had to clear the drifts first, so his crew went at the obstructions with dynamite and cleared them out." (Farnell, 1980).

Farnell's references also reported that, ""from that time forward the bottom land did not flood and structures could safely be built closer to the river" (Farnell, 1980). The U.S. Army Corps of

Engineers (1897) also made reference to large wood in the "North Fork" of the Trask River (one of the Trask's tidal channels), that may have influenced flooding during more moderate events.

> "Now that the South Fork [of the Trask] has been diverted, the jams in this river [North Fork] should be removed, banks trimmed, and sunken logs removed to permit it to carry the flood waters without flooding the farm lands." (Report of the Chief of Engineers, 1896-97, 2nd Session, 55th Congress, pp. 3396-3404; Benner, 1990).

The woody debris in the Wilson and Trask River channels appeared to have been a factor in the historic ecological connection of the river with the surrounding floodplain lands, because the channel wood increased the frequency and degree of periodic overbank flooding. This hydraulic disconnection of the estuary from the floodplains may have begun with the removal of woody debris during the period of settlement, as well as from the practices of disposal of dredge spoil on slough banks and the construction of levees in the tidal reaches.

U.S. Army Corps of Engineers Historical Data on Estuary Wood

The U.S. Army Corps of Engineers was responsible for improving and maintaining the navigability of the Tillamook Bay channels up to the town of Tillamook (Report of the Chief of Engineers, 1889). The agency's work included the construction of dikes to re-route and direct water in an attempt to reduce the deposition of gravel and mud in the navigation channel. The Corps also dredged, and removed "snags" when the wood posed a hazard or impeded navigation (Table 2). The Corps cut trees growing on the banks of Hoquarten Slough when they were modifying this channel for navigational purposes (Report of the Chief of Engineers, 1889; Benner, 1990).

In the annual report to Congress in 1888, the U.S. Army Corps of Engineers reported that in the Hoquarten Slough,

> "...the main obstacles to navigation of the slough to the town [Tillamook], beside its sharp bends, are snags and sunken drift." (Report of the Chief of Engineers, 1887-88, 1st session, 50th Congress, pp.2150-1).

The large wood in the Bay's shallower channels was obstructed travel of small boats to and from Tillamook, the largest town in the area.

> "Tillamook is the principle place of the region; it is on a small slough near the head of the bay...Between these places and Tillamook is a shoal in the bay channel and a bar and sunken drift in the slough, which prevent all but the smallest coasters, and then at high tide, from going to Tillamook..." (Report of the Chief of Engineers, 1887-88, 2nd session, 50th Congress; Benner, 1990).

Between 1890 and 1920, the Corps, and to a limited extent the Port of Tillamook, removed well over 9,300 snags from Bay channels for navigational purposes (Benner and Sedell, 1987; Gonar, J. J. et. al., 1988). Most of these snags were pulled from the channel between Dick's Point near the mouth of the Tillamook River, on up Hoquarten Slough to the town of Tillamook. Some of the remaining were removed from the lower channels of the Trask River. Table 2 summarizes the early snag removal work by the Corps and the Port in the Tillamook Bay area.

Both the snagging and dredging work done in this upper section of the Bay was a continuous project. This area within the river-bay interface in its natural state had the tendency to collect material. In addition, the dredging and snag removal lowered the channel bottom so that it appeared to have readily trapped new material to restore the proportional depth. The U.S. Army Corps of Engineers, and later the Port of Tillamook, had to repeatedly remove snags as higher flows deposited new wood in the navigational channel.

> "...Hoquarten Slough and South Fork of Trask River were thoroughly snagged...The winter freshets made snagging and redredging necessary, and...Hoquarten Slough was again cleared out [snagged] and preparations made to begin dredging." (Report of the Chief of Engineers, 1904-05; Benner, 1990).

Since the sole objective at that time was to provide for transportation within and outside of the Tillamook Bay, sometimes the wood and the disturbance processes within this river-bay system were looked upon as "evil" or unsuitable.

> "The first mouth [of the Trask], locally known as the North Fork, has become clogged up so with timber jams as to divert most of the water into the South Fork. It is proposed to remedy the evil by building a dike across the head of the South Fork and removing the jams from the North Fork..." (Report of the Chief of Engineers, 1895; Benner, 1990.).

Though the records were filled with accounts of wood and its removal in the uppermost section of the Bay, the U.S. Army Corps of Engineers annual reports between the 1880s and 1920 did not note the presence of wood in the lower Tillamook Bay. Snagging efforts were not discussed as part of the 1916 project to dredge a deeper (16 feet) and wider channel from the entrance to Tillamook Bay to Bay City. This may have been either because the focus of this project was on dredging, and so did not list "snagging" as a project task, or that wood removal was proportionately a small element of the project.

However, considering the amount of large wood that was removed over time from the Hoquarten Slough and the reports of snags and wood jams in other channel areas, it seems that large wood could have been present on the tidal flats and in the channels of the Bay. If snags were not obstructing navigation, however, then they would not have been noted by the Corps. The 1939 aerial photographic series flown by the U.S. Army Corps of Engineers (Portland) shows large wood scattered on mud flats around the Bay's border, but the high tide covered the majority of the tidal flats within the Bay so that wood, if it was present, was not visible.

The construction of dikes, the disposal of dredge spoil on the banks of Hoquarten Slough, and the dredging of "short-cutting" channels, may have modified the routing and residence time of large wood, and funneled wood into the Bay rather than retaining it within this portion of the tidal zone.

C. Sources of Large Woody Debris in the Basin

The sources of large woody debris within the Tillamook Bay basin were extensive. Forests of large trees and understory vegetation grew along the river corridors and tributaries, except for along the sections of channels within most downstream reaches within tidal flats and grass marshes (Plate 1).

In the 1850's the majority of the watershed surveyed was described to be forested with hemlock, cedar, and fir. This survey work did somewhat characterize the vegetation on the mountainous lands. However, only a small portion of the mountainous areas was surveyed in the 1850's, and the areas surveyed were generally the limited to the uplands neighboring the Bay and river valleys.

The comments by the surveyors about the unsurveyed areas did suggest extensive forest land. "The unsurveyed part...is mountainous & broken & densely covered with timber..." (General Land Office, 1857, T2S R10W), and, "the balance of the Township is very broken & mountainous & covered with dense forests" (General Land Office, subdivisions, 1857, T1S R9W).

One section of mountainous forest that was surveyed in the 1850's was the land north-east of Idaville. The surveyor described the land and timber as,

> "Surface precipitous and broken — Timber 1st rate Spruce, Hemlock, Yellow Fir, Cedar, Bearberry, Vine Maple, Crab [apple] — Undergrowth Vine Maple, salmon, huckle, thimble berries, Alder, salal, etc." (General Land Office, 1857, T1N R9W).

Another area surveyed was the land in the lower mountainous area just to the west of the Tillamook River. The area and vegetation was described as,

> "Surface very broken —Timber 1st rate Spruce, Hemlock, Yellow] Fir, Alder, Maple — Undergrowth Salmon, Thimble & Huckle berries — salal, Maple & Elder." (General Land Office, 1857; T2S R10W, p.34).

Streams ran through these lands, and were often in deep ravines, or adjacent to fairly steep slopes. This type of landscape could provide opportunity for falling wood to reach a stream and, if the stream was constrained with limited floodplain, could flood with significant force to transport wood.

The valley floor lands and river corridors supplied wood to the rivers and Bay. A good part of these lands within the floodplain were probably wooded.

> "Tillamook River is by far the best stream for navigation, but its banks are low and overflowed for miles, affording at no place on its navigable part, it is judged, a suitable landing nor a convenient and accessible point for the trade of the settled country." (Report of the Chief of Engineers, 1887-88, 50th Congress, 2nd session; Benner, 1994).

The 1856-57 original township survey field notes characterized a fairly well-established wooded riparian corridor, with large portions of the floodplain along the Kilchis, Wilson, Trask, Tillamook, and Miami Rivers being wooded as well (Plate 1). An 1857 bottomlands description of lands adjacent to the Tillamook River at today's river mile 4 reported,

> "Land 1st rate —Timber 1st rate Cottonwood, Spruce, Hemlock, Y. Fir, Maple, Alder, bearberry & crab [apple] — undergrowth Salmon [berry], Thimble, Huckle, salal, maple, elder, etc." (General Land Office, 1857; T2S R10W p.28).

The trees noted along a survey mile section on the bottomlands near the Trask River (at the present river mile 2.5) ranged from 16" to 156" diameter hemlocks, from 32" to 84" diameter spruce, a 16" and an 18" diameter alder, and an 8" maple. The land and timber was described as,

> "Tide Land bottom level -—Timber Spruce, Hemlock, Y. Fir, Alder -- undergrowth crab [apple], Salmon berry, V[ine] Maple, Huckleberry." (Original Township Survey Notes, 1857; T1S R10W:36-31 p.19-T2S).

Trees were almost always readily available for survey bearing trees along river banks on the valley floor. Table 3 gives an example of vegetation used as bearing trees by 1857 surveyors along the tidal sections of the sloughs tributary to Tillamook Bay. Though these data do not represent a random data set, because surveyors presumably selected bearing trees for certain characteristics, they do demonstrate the size of the trees that were sources for large wood.

Delivery of Wood from the Watershed

A number of landscape processes delivered wood to the Tillamook Estuary, and most were episodic in nature and of various magnitudes. Floods, landslides and debris torrents, fires, and river bank erosion all played a role in moving wood through the landscape. Flood events, though periodic, were major process by which large woody debris traveled from the watershed to tidal areas and the ocean. Historical accounts of amounts of wood transported during major storms included William Brewe's, who was traveling by land along the Northwest coast soon after the major storm of 1861. An excerpt of his narrative reported that,

> "The floods of two years ago [1861] brought down an immense amount of driftwood from all the rivers along the coast, and it was cast up...in quantities that stagger belief. It looked to me as if I saw enough in ten miles along the shore [Crescent City] to make a million cords of wood. It is thrown up in great piles, often half a mile long, and the size of some of those logs is tremendous". (Brewer, 1863).

James Swan's description of a storm along the coast of Washington and Oregon in 1857 gives a good example of how much wood once was transported to the open ocean during major events,

> "The next morning [after a storm] we found ourselves about thirty miles to the westward of the Columbia River, from which a huge volume of water was running, carrying in its course great quantities of drift logs, boards, chips, and saw dust, with which the whole water around us was covered." (Swan, 1857).

Along the Oregon coastline, wood was historically very abundant. Colonel Gillespie, a U.S. Army Corps of Engineers representative (1879), reported that, "the north shore [of the Umpqua River mouth] is a low sand spit, covered with drift wood." An 1884 U.S. Army Corps map of the mouth of the Coquille River marked that the sand spits were 'covered with heavy drift."

Anthropogenic Sources of Wood

As natural sources of wood inputs declined over time, human sources contributed large wood to tidal rivers, bays, coastal shorelines and the ocean. In the Tillamook system, for a period of time some channels were used to transport saw logs to the mills. Logs were also stored in booms in the tidal rivers. There were opportunities for logs to escape during storage or transport.

Wood pilings, docks and other wooden structures also added wood structure to tidal rivers and bays. Wood was also probably disposed of into channels with the clearing of land, though the Rivers and Harbors Act of 1899 prohibited the dumping of refuse into navigable waterways.

Fires in the basin created sources of downed wood, and so opportunities for pulses of wood to reach the Tillamook Bay during floods. The 1856-57 Original Township survey notes made reference to fires on the lands in the southwest section of the lower mountains. By the 1880s, fire(s) had burned large patches of the mountainous lands in the watershed. It is difficult to determine the degree to which these fires may have contributed to estuary wood, especially the linking of these very early fires with flood events.

Present Day Losses of Wood

Present day amounts of wood in tidally-influenced reaches of river and along the coastal shoreline are smaller in both volume of wood and the size of the wood. Aerial photographic study by Benner and Sedell (1987) documented a 73 percent reduction in the volume of wood at four river mouths (Tillamook, Siuslaw, Umpqua and Coquille) between 1970 and 1985.

A number of factors could account for this reduction in wood. One factor is a normal decline in wood over time after a major event such as the 1964 flood. However, 1970 amounts of wood were noticeably less than in 1939 aerial photography. Forest practices regulations in the 1960s and 1970s directed the removal of wood from streams adjacent to logging operations, and all wood was often removed, both naturally-occurring as well as logging refuse. There are currently fewer anthropogenic inputs, primarily because logs are no longer transported by water. Wood stove use increased during the period of study, and large wood removal of newly downed trees by individuals for home wood stoves has increased. Between 1972 and 1984 the number of Forest Service free-use wood permits that were issued by the Pacific Northwest Region increased eight-fold (Gonar, et. al., 1988).

Table 7
Descriptions of Large Woody Debris in Tidal Sections of Tillamook Bay Rivers.
Descriptions were given in the 1857 original township survey field notes.

Location	Drift Wood and Jam Descriptions from 1857 Original Survey Notes
[1] Trask River, "South Fork"	"Right south of this point the slough is obstructed by drift, and therefore it was thought not advisable to meander any further up this Slough."
[2] Trask River, "North Fork"	"As this slough becomes narrow, shallow, and obstructed with drift-and the main route to Ouquarten settlements is by the Ouquarten Slough, it was though[t] it would be no advantage to meander this [Trask] slough any further up it."
[3] Slough off of Hoquarten Slough	"The slough here being narrow & obstructed by drift - crossed [over slough] on drift."
[4] Wilson River	"Drift in river...[at 13.00 chains] leave drift", and at same site, "river full of drift." [13 chains = 860 feet of channel length]
[5] Wilson River	"River obstructed by drift...[at 17.00 chains] Leave drift." [17 chains = 1,130 ft., & other bank 11.00 ch.= 730 ft. Average length of this jam, 800 feet.]
[6] Slough off of Wilson River	"Slough here becomes filled with drift and is very narrow -- no use to meander further...across drift."
[7] Kilchis River	"To a point where the [Kilchis] river becomes shallow and obstructed by drift it was thought useless to meander it any further up."
[8] Tillamook River	"The Tillamook River is navigable from Section 7 to the ocean--and would be so for small steamboats if cleared of drift."

Table 8
U.S. Army Corps of Engineers Removal of Snags in the Tillamook Bay System
(Chief of Engineers, 1886-1922; Benner, 1990).

Fiscal Year	Description	Agency	Snags removed	Other Work
1887-88	"is a shoal in the bay channel, and a bar and sunken drift in the [Hoquarten] slough..."		---	
1887-88	"...Hoquarton Slough, is very crooked and has a width of about 50 feet at Tillamook...The obstructions are a bar, called Dry Stocking Bar, across the mouth of the slough, and some sunken drift on the bottom of the slough a short distance below Tillamook. At mean low water there are only about 18 inches of water over the former, and only 3 feet over the latter."		---	
1887-88	"...The main obstacles to navigation of the [Hoquarten] slough to the town, besides its sharp bends, are snags and sunken drift. People interested in navigation to Tillamook want the snags and drift removed, the Dry Stocking Bar channel deepened..."		---	
1888-89	"The project is...to deepen the water over Dry Stocking Bar at the mouth of Hoquarton Slough...by constructing longitudinal and spur dikes and shore-protection works, and to cut down overhanging trees, and do snagging work along Hoquarton Slough, as far up as Tillamook City."		---	
1889-90	"Hoquarton Slough was cleared of snags as far as Tillamook City."	Corps	snags removed # not mentioned	
1893-94	"...construction of the Dry Stocking Bar Dike, 900 feet in length, and the construction of 1,200 feet of the Junction Bar Dike from Dicks Point northward."	Corps	---	Dikes
1894-95	"The water on Dry Stocking Bar has not deepened to any great extent owing to the deflection of the waters of the Trask from Hoquarton Slough by jams."		---	
1894-95	"The first mouth [Trask River], locally known as the North Fork, has become clogged up so with timber jams as to divert most of the water into the South Fork. It is proposed to remedy the evil by building a dike across the head of the South Fork and removing the jams from the North Fork..."			

Table 8. U.S. Army Corps of Engineers Removal of Snags in the Tillamook Bay System (Chief of Engineers, 1886-1922; Benner, 1990).

Fiscal Year	Description	Agency	Snags removed	Other Work
1895-96	"It [improvement] also includes...the removal of log jams in the north fork of Trask River...'		---	
1895-96	"Work during the past year consisted in repairing existing dikes, constructing dikes across the head of Stillwell Ditch; laying flat protection between Junction Island Flat and the Middle Channel dike, excavating a channel between the north and main channels, and enlarging Stillwell Ditch."	Corps	---	dikes, & excavation
1896-97	"In addition to the contract work some troublesome trees were cut along the banks of Hoquarten Slough, and about 300 pounds of high explosives used to in removing snags found embedded in Dry Stocking Bar, with a resulting increase in depth of about 1 foot."	Corps	blasted snags embedded in channel cut trees on bank	
1896-97	[Channel Structures Constructed 1896-97] Trask River Ditch Dike south of Junction Islands Cut across mud flats in the vicinity of Bay City Flat protection from north end of Middle Channel Dike Dike north of Junction Island Dike North Fork Trask River Dike South Fork Trask River Repairs to existing dikes	Corps	---	Dikes & excavation
1896-97	"...felling and removing over-hanging trees from along the banks of Hoquarten Slough, 38 trees being removed at a cost of $64. By blasting and other means there were also removed from Dry Stocking Bar 29 large snags, being from 1 foot to 2 feet in diameter, all of which were more or less buried in the sand. This has caused a deepening of the water on the bar of about 1 foot."	Corps	cut 38 trees from bank 29 large snags	

Table 8. U.S. Army Corps of Engineers Removal of Snags in the Tillamook Bay System (Chief of Engineers, 1886-1922; Benner, 1990).

Fiscal Year	Description	Agency	Snags removed	Other Work
1896-97	"Dry Stocking Bar.--This has been, and is now, one of the worst places on the route from the ocean to Tillamook...The removal of snags that will be found buried in shoal will aid this place very materially."		---	
1896-97	"This slough [Hoquarten]...is from 50 feet to 80 feet wide, and has a number of very sharp bends; its banks slope almost vertically, and are timbered with heavy growth. The slough is tidal;...it is full of snags and drift buried in the mud bottom;...while if these snags were removed, the sharp bends eased up, banks trimmed of the heavy timber growth, the slough would be vastly improved, and carry at least 8 feet at low tide.		---	
1896-97	"Trask River, North Fork.--Now that the South Fork has been diverted, the jams in this river should be removed, banks trimmed, and sunken logs removed to permit it to carry the flood waters without flooding the farm lands."		---	
1896-97	"Future maintenance.--One of the most serious troubles with this bay is caused by the large number of snags and fallen trees that are carried on in the floods, and which eventually sink on the shoals and become buried in the same..."		---	
1899-1900	[?]			
1900-01	5 spur dikes on Hoquarten Slough at Dry Stocking Bar 2 spur dikes opposite old Wilson River 1 spur dike, "on east side of selected channel"	Corps		dikes
1902-03	"Up to the present time 1,245 snags have been removed and Hoquarten Slough dredged to a point below Dry Stocking bar..."	Corps	1,245 snags	

Table 8. U.S. Army Corps of Engineers Removal of Snags in the Tillamook Bay System (Chief of Engineers, 1886-1922; Benner, 1990).

Fiscal Year	Description	Agency	Snags removed	Other Work
1903-04	"During the fiscal year...376 large and 770 small snags were removed from Hoquarten Slough, and placed on the bank and cut up."	Corps	376 large snags 770 small snags	
1904-05	"...Hoquarten Slough and South Fork of Trask River were thoroughly snagged...The winter freshets made snagging and redredging necessary, and...Hoquarten Slough was again cleared out [snagged] and preparations made to begin dredging."	Corps	snags removed no # given	
	1904: "Hoquarten Slough was snagged from Tillamook City to its mouth and all overhanging trees were cut down. 1905:"...during [June] Hoquarten Slough was thoroughly snagged."		snags removed no # given overhanging trees cut	
1905-06	"In addition to the dredging, 154 large and 895 small snags were removed from Hoquarten Slough."	Corps	154 large snags 895 small snags	
1907-08	"At the close of the last fiscal year the work of snagging Hoquarten Slough...was in progress. This work...extended over 5 miles of the channel, from the town of Tillamook to a point below Dicks Point. Three hundred and forty-two large [snags] and 2,734 small snags were removed, and 48 overhanging trees were cut away. The snagging work... cost about $1,500."	Corps	342 large snags 2,734 small snags 48 overhanging trees	
1908-09	"Snagging...Hoquarten Slough...between Tillamook City and Memaloose Point. This stretch was thoroughly snagged, and approximately 196 large snags and 1,910 small snags and trees were removed from the channel..."	Corps	196 large snags 1,910 small snags & trees	
1909-10	"Snagging and dredging in the bay channel between the town of Tillamook and Hobsonville."	Corps	---	
1910-11	"253 snags were removed from the channel." 175 snags removed from Hoquarten Slough 45 snags removed from Hoquarten Slough	Corps Port(T) Corps	78 snags 175 snags 45 snags	

Table 8. U.S. Army Corps of Engineers Removal of Snags in the Tillamook Bay System (Chief of Engineers, 1886-1922; Benner, 1990).

Fiscal Year	Description	Agency	Snags removed	Other Work
1911-12	"...in Hoquarten Slough, maintaining and straightening the old Trask River, and excavated 73,763 cubic yards of material...In the course of the dredging 260 large snags were encountered and removed from the channel.	Corps & Port(T)	260 large snags	
1916-17	"No work of maintenance of the 9-foot high-water channel between Bay City and Tillamook was done during the year except the removal of a few snags from Hoquarten Slough Channel...amounting to $457.93..."	Port(T)	a few snags	
1917-18	"14 large and 32 small snags from Hoquarton Slough.."	Corps	14 large snags 32 small snags	
1919	"The act of March 2, 1919 [Federal], abandoned that portion of the existing project relating to the channel from Bay City to Tillamook [including Hoquarten Slough]."		-----	
		TOTAL	9,236+ snags(1) 86+ overhanging trees (1)plus a number of snags not quantified in reports	

Table 9. Meander Post trees from 1856 survey for Township 1 South Range 10 West, along river banks near Tillamook Bay.

River/Slough	Tree Type & Diameter	Tree Type & Diameter
Kilchis River	16" spruce	3" willow
	8" crab apple	8" crab apple
	mound	mound
	mound	?
Wilson River	13" spruce	40" spruce
	15" spruce	32" spruce
	4" spruce	8" crab apple
	4" crab apple	11" spruce
Hall Slough	30" spruce	4" bearberry
	16" spruce	4" bearberry
	30" spruce (post)	-----
	8" spruce	24" spruce
	8" bearberry	8" bearberry
	56" spruce	?
Hoquarten Slough	12" spruce	16" spruce
	24" spruce	12" spruce
	32" spruce	28" spruce
	40" spruce	44" spruce
	48" spruce	?
Trask River, N. Fork	16" spruce	2" crab apple
	28" spruce	16" spruce
	6" crab apple	4" crab apple
Trask River, S. Fork	22" spruce	19" spruce
	50" hemlock	6" bearberry
Tillamook River	mound	mound
	mound	mound
	16" spruce	2" spruce
	4" crab apple	6" crab apple
	8" crab apple	48" spruce
	40" spruce	6" crab apple

V. Tillamook Valley Historical Landscape Mapping[4]

A. Introduction and Methods

A map (Plate 1) has been created which characterizes the general features of the 1850's Tillamook Bay valley area landscape. This map portrays the vegetation community locations and types, and the locations of the larger swamp and marsh areas as noted by early survey work. The map was primarily based on the 1850's General Land Office original survey notes. Both township and donation land claim notes provided data for this map. Soils and floodplain mapping of the area also contributed to the development of this map, and served to test the information provided by the survey notes and to link survey points into an estimated boundary.

It should be noted that this map is a characterization of the 1850's landscape, and does not provide boundary delineations. However, because it is based on data collected in the 1850's that has been verified with other information, this map is a good representation of the form and features of this historical landscape.

The survey work in the Tillamook Valley area was done in 1856 and 1857. The mountainous areas were not surveyed until the 1870s and 1880s. The 1850's survey notes provided several forms of data.

One data set was created when the surveyor used "bearing trees" to mark the locations of quarter section points, survey corners, and meander posts. The meander posts were placed along a survey line at the Bay edge and the river banks and so provided data relating to riparian vegetation. Although these data are somewhat biased, because the surveyor was somewhat selective in the tree species and size, there is still much that can be discerned from this information. For example, the distance of the bearing trees from the survey corner indicated tree availability and, when alders were used as bearing trees, the suggestion is that there were many alder in the area. When there were no trees available, the surveyor planted a charred stake along with a dug mound and trench. This survey procedure was a fairly sure sign of being in "prairie", a grass marsh or tidal area, or in the mountains in a burned forest.

Another data set was created as the surveyor walked along the township boundary, and then walked the lines that subdivided the township into one-square-mile parcels or sections. As the surveyor walked these lines and marked survey corners at appropriate points, he also noted significant changes in the landscape. Examples included a record of entering timber and leaving prairie, or crossing a stream or reaching a river bank. These points were noted by distance from the last survey corner, though the measurement was rounded to the nearest "chain" (one chain is equivalent to about 66 feet) or might in some cases have even been an estimated number that the surveyor created after finishing the mile. Although approximated survey line locations may be inadequate from a present-day surveyor's perspective when determining property boundaries, these historical data are sufficient to characterize the nature of the historical landscape. It is interesting, though how often the survey notes correlated well with changes in topography on the 1:24,000 U.S. Geological Survey maps, and changes in vegetation communities correlated with changes in soil types.

The third major data set was created by the surveyor when he summarized the vegetation and land features at the end of each mile. The surveyor generally also wrote a landscape description after surveying the township exterior lines and subdivision lines.

Not all of the 1856-57 survey work was accurate or thorough, however. On two occasions the survey notes were in a reversed direction relative to the topography. Another limitation of the survey notes was that the surveyor sometimes referred back to former descriptions rather than describing each mile separately. This generally did not create a problem except for the few times where the survey work had moved to upland areas and the referenced description had been of the valley floor. Fortunately, there were enough miles of data to screen out obscure references or gaps in the information.

[4] Patricia A. Benner, Principal Author.

Smaller landscape features such as the locations of small pockets of prairie or marshlands may not be represented on this mapping work if a survey line did not transect that landscape feature at some location. Even though present-day data such as hydric soil locations may have suggested former wetland sites, they were not drawn into the map unless there were other historical data to complement the hydric soils data.

All useful data for the mapping work were extracted from the original, handwritten survey field notes and placed on map-type data sheets. The field notes were closely compared with U.S. Geological Survey maps (1:24,000 scale) as the data were being collected. The data were then consolidated and somewhat synthesized onto mylar transparent sheets, and then compared to soils and floodplain data. All of this available information, as well as 1939 aerial photograph information, were then synthesized to create a draft map. This step generally involves analysis and evaluation of not only the major data, but also taking advantage of secondary indicators such as road, trail and Native American village locations. There was enough information to create a reliable map that characterizes the Tillamook Valley area in the 1850's.

B. Characterizing the 1850's Landscape

Many of the 1850's landscape features in the Tillamook Valley, Oregon, area were much different from the landscape of the late 20th century. Since this landscape has been largely modified over the past one hundred and forty years, it is useful to develop the best possible baseline representation of the landscape which has been created and maintained through a number of ecological processes, and has provided for a diverse set of resources. One window into that period of time is provided by the early data and descriptions of the landscape most thoroughly covered in the original survey field notes from 1856-57. This text is a supplement to the map created from these early data

Tillamook Bay

The original survey work by Surveyor Snowden (1856) described the Tillamook Bay as,

> "...shallow and when the tide is out leaves the mud bare on about two-thirds of its surface...", and "Tillamook Bay is generally very shallow, tho' there is said to be good channels for small vessels up the Ouquarten[sic] Slough & Tillamook River."

This 1850's first-hand observation of the Bay is supported by other references and data sets. However, it may be a common belief that the Bay was a much deeper water body, with a much small area of exposed flats during low tide, prior to the 1900s fires. This description, along with the knowledge of the ongoing Bay channel and slough dredging that began in the late 1800s, gives a more thorough context to the Bay sedimentation story.

Tidal Marshes

For up to about one mile from the edge of Tillamook Bay areas were valley lands that were repeatedly described by Surveyor Snowden (1857) as,

> “Soil 1st rate for grazing, tideland level, cut up with fissures, occasionally overflowed by the tide.”

No trees were used to mark survey corners or meander posts on the banks of the sloughs. Only one reference was made to trees in this part of the landscape, and that was down near the mouth of the Tillamook River where the surveyor commented, "Timber, a few scattering of spruce." The land was surveyed in September and early October, a drier time of year. Both the survey descriptions of this area and hydric soil mapping (Coquille and Brenner silt loam) suggest that before levees were constructed, this land was regularly inundated by Bay waters.

Lower Wooded Tidelands

The lands immediately adjacent to the tidal marshes were described in the original survey notes as "broken with tide fissures" and were forested with a variety of tree species. The forests contained either "1st and 2nd rate timber," depending on the section surveyed. One example is the description of the land adjacent to the lower reach of the Trask River and Hoquarten Slough.

> "Soil 1st rate. Land broken with tide fissures. Timber 1st rate Spruce, Crab [apple], Hemlock, Cedar, Maple and Alder."

The undergrowth in the lower wooded tidelands included crabapple, maple, hazel, Salmon berry, huckleberry & other briers.

The lands just upriver of the tidal marshes between the wide, slough-like sections of the Kilchis, Wilson, Trask, and Tillamook Rivers were all described as broken with tide fissures, and the survey notes commented that this part of the valley landscape was "subject to inundation in heavy storms." A large proportion of these lands are mapped as hydric soils by the soil survey (Bowlsby and Swanson, 1964). A well-drained bottomland soil type (Nehalem series) begins to be present along what was probably the eastern border of this tidally-fissured land.

River Floodplain Bottom Lands

The river floodplain lands that extended east from the tide-fissure wooded lands to the eastern end of the main valley, and up the Tillamook and Kilchis River valleys, were generally described by the survey notes as "river bottom lands." These floodplain lands along the lower reaches of the Kilches, Wilson, Trask, and Tillamook Rivers can be divided into two categories: the lands that were described to be within the upper reaches of the tidal river, and the portion of the bottomland that was beyond the area of typical tidal influence. However, there was no difference in the descriptions of the vegetation for these two floodplain bottomland types.

Surveyor Snowden (1856-57) reported that the river bottom tidal lands in the area of Tillamook River were,

> "...1st rate tide bottom. Timber 1st rate Cottonwood, Spruce, Hemlock, Yellow Fir, Maple, Alder, Bearberry and Crab [apple]. Undergrowth dense Crab, Salmon, Thimble and Huckleberries, Salal, Maple, elder & c."..."Rich tide land bottom with dense undergrowth. Timber first rate..."

The land between the Wilson River and Hoquarten Slough was described as:

> "Land level. Tideland subject to inundation in heavy storms. Timber 1st rate Spruce, Hemlock, Yellow Fir, Alder, Vine Maple. Undergrowth Hazel, Salmon berry, Maple, Crab [apple], Huckleberry, salal & c."

A representative account of the lands in a non-tidal bottomland floodplain was for a survey section line in an area southeast of the town of Tillamook.

> "Land 1st rate river bottom, level. Timber 1st rate Cottonwood, Spruce, Hemlock, Maple, Alder, Yellow Fir, Crab [apple]; Undergrowth dense, Salmon [berry], Thimbleberry, Huckleberry, salal, Maple, Elder and Crab."

Although this floodplain description did not mention cedar, other section line notes included cedar in the list of trees.

Higher-Elevation, Gently Rolling Timbered Valley Lands

The remainder of the timbered valley lands were outside of the floodplain on river terraces, along the outer areas of the valley floor, or in other ways removed from the floodplain. The timber and understory were generally reported to be the same with the exception of cottonwood which was not mentioned in these areas.

Historical Forest Communities as a Wood Source

One of the predominant features of the 1850's Tillamook Bay Valley landscape was the extensive forested area. The valley bottomland trees that were used as survey bearing trees were generally substantial in diameter. Forty to eighty-inch diameter spruce, and twenty to sixty-inch hemlock were common used as bearing trees.

The species of trees mentioned in the survey notes were probably black cottonwood (sometimes called "Balm" or "Balm of Gilead"), Sitka spruce, western hemlock, big leaf maple, red alder, the grand fir (called "yellow fir"), and western redcedar (Burns and Honkala, 1990; Bowlsby and Swanson, 1964). The surveyor sometimes referred to the undergrowth maple on the valley floor more specifically as "vine maple." Both maple species were likely to be present in the understory.

Alder was a common occupant of the upland and valley timbered lands, and the data suggests that alder stands, especially associated with creeks, were a landscape feature. At about mile 13 on the Tillamook River (U.S. Geological Survey maps, scale 1:24,000), the 1857 survey line traveled about 1,500 feet through an "alder bottom" adjacent to a bend in the Tillamook River.

At the south end of Township 1 North Range 10 West the 1857 survey line ran through "alder timber" at the edge of a small prairie posket in the timbered foothills.

The presence of black cottonwood is an indicator of flood disturbance. Cottonwood seeds germinate on bare, exposed fine soils, such as the silts deposited during a flood. The seeds are viable for only several weeks, and the seedlings require sunlight so do not compete well in already-vegetated areas (Dykaar, 1995). Channel changes and other disturbance processes create opportunities for succeeding generations of cottonwood stands. The cottonwood was more frequently mentioned within the northern portion of the main valley floor, but appeared throughout the notes, including within the Tillamook River valley. The exception was within the Kilchis and Miami River lower valley areas.

Although cottonwoods were repeatedly reported by the township surveyor, and mentioned several times by the donation land claim surveyor, they were not used as survey bearing trees, so a better sense of their size and distribution was not possible from the survey notes. The cottonwood is interesting from an ecological perspective because when in water it often sinks and creates subsurface aquatic habitat. When a tree is toppled it will readily grow new shoots that may help to maintain a cottonwood population on the floodplain.

The historical presence of trees on the bottomland floodplains and along the river banks as documented by the 1850's survey notes created a source for large wood in the lower river and Bay aquatic systems. Bank erosion through natural disturbance processes delivered trees to the channel, many of which anchored to the bank for a period of time. Timber and a heavy understory served to slow floodwaters that in turn reduced soil erosion and in some areas increased sediment deposition.

The upper end of the Bay and tidal sloughs were natural catchment areas for sediment and large wood (see report section on large wood). Survey work documented the presence of wood up tidal sloughs, and the survey line was often aborted when the surveyors reached a drift jam. The surveyor team reported crossing over sloughs on the wood to meander the other channel bank. A surveyor (1859) wrote that he "crossed [the Trask River] on drift wode[sic]" while surveying the boundary of Edrick Thomas' Donation Land Claim #44. The city of Tillamook is located in part on the buildable portion of this claim, and the point where he crossed the Trask River is just to the southwest of the town. Surveyor Snowden also reported large channel wood.

> "The Tillamook River is navigable from section 7 [about five miles upriver] to the ocean, and would be so for small steamboats if cleared of drift."

The large wood not only collected within the aquatic zones of the tidal sloughs and upper Bay channels, but was probably deposited along the edge of the tidal marsh lands where the wood functioned as nurse logs for young conifers and other vegetation.

Dry Prairie

If a quick estimate were to be made of the approximate locations of many of the 1850's prairie areas, an easy method would be to note the sites of the first donation land claims (Jensen, 1995). There were actually two types of lands noted as prairie. One was a "wet prairie" or "swamp prairie." This type of grassed area is grouped with wetland-type locations. The main type of prairie land found in the Tillamook Bay area are the "dry prairies" and "high prairies."

There was a very strong correlation between two soil types and the prairie locations. The prairies located north in the Bay City area were associated with Winema silt loam soils, and the rest of the prairie areas were associated with Quillayute silt loam soil. The Quillayute silt loams are deep and well-drained soils located on stream terraces (Bowlsby & Swanson, 1964). Although not all of the areas of this soil were in prairie, practically all of the southern prairie lands identified by the survey notes were located in the area of the Quillayute soils. The prairie lands were also up on higher valley ground above the 100-year floodplain.

It was fairly easy to feel confident about the general location of the prairie lands because of the use of mounds and trenches to mark a survey corner. Surveyor Snowden (1856) and the donation land claim surveyor (1859) identified boundary points when they noted, "leave prairie, enter timber." And general descriptions at the end of a section mile, such as "Soil 1st rate, mostly prairie..." completed a nice set of indicators.

Higher Valley Lands

Although there was a small portion of prairie land in the lowest reach of the Tillamook River area, the majority of lands in the Tillamook River valley were predominantly in timber. After the Surveyor Snowden (1857) walked the valley lands in Township 2 South Range 9 West, he noted that,

> "The soil...is perhaps 1st rate, tho' there is perhaps less than 3 sections of clear prairie. The balance is heavily timbered and the underbrush dense and scarcely passable."

Marshy and Brushy Swamplands

There were several areas noted in the survey work that, in their 1850's state would have been classified as wetland. Outside of the tidal marsh lands and tidal bottomlands that appear to have been predominantly wetland, these other areas tended to be located in smaller pockets, or along a swale-like water course.

Holden Creek

The three-mile corridor of brush-vegetated lands within a large area of prairie lands just south of the town of Tillamook was likely to have been Holden Creek prior to straightening and ditching. The creek water appeared to have been within a channel in the foothills, but lost a defined channel and spread out into a swale or wetland area on the valley floor. About a mile before entering the Trask River, a defined channel reappears. Table 10 lists the descriptions of this swale wetland, beginning at the upstream, or eastern end of this corridor.

One site north of Wilson River along the west boundary of Township 1 South Range 9 West the surveyor noted a lake or marsh. Associated with this shallow lake was a larger "swamp" area. "Swamp prairie" lands and "wet prairies" were noted near the mouth of several tributaries to the lower Tillamook River. Although it seemed that some alder, hemlock or other trees may have been associated with these lands, grasses dominated many of these wet areas.

Mountainous Uplands

The majority of the mountainous land in the Tillamook Bay watershed was not surveyed until the 1870s, 1880s and 1890s. Being mountainous, steep and "very broken", this "rough mountainous land unfit for settlement" was not considered worth surveying, and so only the township boundaries were surveyed. The cadastral maps drawn in the 1800s from the survey notes (Figures 39 a-d) indicate the upland areas that were not surveyed in the 1850's. These upper watershed lands include areas that are now being recognized for their function as ecological reserves (Garono, 1995).

A limited amount of upland immediately adjacent to the Tillamook Bay valley lands was surveyed in the 1850's. A description in the survey notes of the mountainous land between the Tillamook River and the ocean was,

Table 10
Holden Creek 1857 Description and Data.

Site	Survey Notes Description	Location (Township 1S Range 9W)
1	"Creek, 10 links (7 feet) wide"	In foothills near Balmer Hill, sec. 26
2	No channel noted; alders as survey bearing trees in area; 12" and 14" in diameter	Donation Land Claim #39
3	Two alders used as survey bearing trees; 5" & 8" in diameter	NE corner of Donation Land Claim # 37
4	"Leave prairie & enter brush;" after 460 ft. "leave brush & enter prairie" "Timber none; undergr. willow & briers	Survey line between sections 28 & 27
5	Two alders used as survey bearing trees; 6" & 10" in diameter	NW corner of Donation Land Claim # 37
6	Leave prairie and "enter swamp; after 660 ft.,"leave swamp" & enter prairie.	Survey line between sections 29 & 28
7	"Edge of brushy swamp; 12" alder for bearing tree	NW corner of Donation Land Claim #38
8	"Corner in willow brush;" 2 alders as bearing trees, 6" & 13" in diameter	SE corner of Donation Land Claim #43
9	Leave prairie & "enter timber;" at 900 ft. "leave swamp & enter prairie." At 2 ch. (133 ft.) a channel is noted again as line crosses a "slough"	Survey line between sections 30 & 29
10	Two creeks noted; the west one 10 lks. (7 ft.) wide & the east creek 50 lks. (33 ft.) wide. Both are within a 1,060 feet-wide alder & willow "swamp"	Survey line between sections 30 & 31
11	Water enters the Trask River	In section 31

"Surface very broken. Timber 1st rate Spruce, Hemlock, Y[ellow] Fir, Alder & Maple; Undergrowth , Thimble and Huckle berries, salal, Maple & Elder." [4] T1SR9W

A typical landscape description of the mountainous lands was given by Surveyor Handley (1881) of the lands in the Kilchis River watershed along eastern boundary of Township 1 North Range 9 West.

> "This line runs over rocky rough and craggy mountains and deep and precipitous creeks and gulches the greater part of its length. The soil is mostly 3rd and 4th rate. The timber is 2nd, 3rd rate and 4th rate, consisting of Fir, Hemlock, Spruce and cedar. Undergrowth very thick Vine Maple, Salal, Salmon brier and Whortle berry..."

Surveyor Snowden wrote a general description of the mountainous lands after he surveyed the line between Township 1 North & Township 1 South, Ranges 7, 8 and 9 West in 1856.

> "These last three ranges, rg. 7,8 & 9 west present nearly all the same features as to unevenness of surface - quality of soil & rock, vegetation and streams. --

> Up to this point, we are passed over nothing but mountains and spurs, of the roughest kind, varying from 300 ft. to 1,500 ft. high and springing from the canions[sic] from 30 to 100 feet perpendicular only... The valleys are only from 50 lks. to 100 lks. wide. -- The soil thin and stoney but of 2nd rate quality; but from its unevenness of surface and inaccessibility can never be worth cultivation...It is heavily timbered, mostly with Spruce, Hemlock & Cedar; where steep rugged and large from 3 to 10 feet diameter; where more level straight, clear[?], tapering, smaller and thicker, from 1 to 3 feet diameter. -- The streams rapid, clear and pure water..."

In several upland areas the 1850's survey team came across a few patches of burned timber, possibly burned during the Nestucca coastal fire in 1848. The 1873 and 1883-84 surveys of the mountainous lands reported significant acreage of burned timber in some portions of the watershed (see section of report on historical fires). There was some geographical overlap of the 1850's and 1870s surveys, and the data suggest that some of the forest fires may have occurred between these two dates. A typical 1880s description of the burned watershed lands was written by Surveyor Meldrum in 1884 while walking the south boundary of township 1 south range 9 west.

> "Land Mountainous, Soil 4th rate. Densely covered with forests of Hemlock, Fir, Spruce and Cedar deadened by fires. Thick undergrowth of Vine Maple, Salmon berry, Alder, Elder, Spruce, and Hemlock."

River and Stream Channels

Most of the river and stream channel courses were not drawn on the historical landscape map created for this report. Instead, each intersection of a survey line with a stream or river was noted on the map.

Except for the survey-stream intersection points, there were not sufficient data in the survey notes to determine the historical path of the streams and river channels within the fairly level terrain unless the surveyors did a "meander survey" of the water course. To do a meander survey, the survey team walked along the river bank in variable-length segments, noting the distance walked for each segment and measuring the new directional angle each time the channel changed course. *Be aware that, unless a river channel was surveyed, any channel course drawn on historical survey maps was generally only a guess on the part of the map-maker as the survey points were connected.* In the Tillamook Bay area, the Bay shoreline and the downriver segment of the larger rivers were surveyed in 1857.

Surveyor Snowden sometimes described a river at a survey line channel crossing. He described the main fork of the Kilchis River in the mountainous portion of the watershed as being "3 feet deep, gravel bottom" (Township 1 North Range 9 West). At the intersection of the north boundary of Township 1 South Range 9 West (section 5) with the Kilchis River, the channel was described as having a "Fast current, gravelly bottom, 100 links [66 ft.] wide." When the same section line was resurveyed by Meldrum in the summer of 1884, he noted that,

> "The Kilchis River has changed its bed at this point, about 3.50 chains [230 feet] north of old channel which has filled with gravel, sand & c."

The Wilson River also changed course in the valley reach between the time of the 1850's survey and the 1939 aerial photography at about river mile 5.

Native American Sites

The survey notes included documentation of Native American sites around the Tillamook Bay. After surveying Township 1 North Range 10 West, Snowden (1857) noted that,

> "There are about from 16 to 18 Indian huts around the Bay in this township. The main village is in Section 21 [to the west of the mouth of Miami River and at the present site of the town of Garibaldi]."

However, in Township 1 South Range 9 West he commented that,

> "The chief residence of the Tillamook Indians is at Kilchis Point in section 11 [on a prairie point to the west of Kilchis River mouth]. There is however another village in section 12."

The section 12 village was to which he referred he sited at the mouth of Kilchis River on lands that most likely would have periodically flooded. An "Indian Hut" was noted in the survey notes to be on the spit on the west side of the Bay, and three "Indian Huts" were noted to be on the south side of the mouth of the Miami River.

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