KILCHIS WATERSHED ANALYSIS

TILLAMOOK BAY NATIONAL ESTUARY PROJECT

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EXECUTIVE SUMMARY

Introduction

This section presents a brief summary of the findings from the analysis chapters. It proceeds roughly in the order that the chapters are in, but the same topic may appear in several places throughout the text. Chapter 10 is a synthesis of the findings of this study for the priority resource issues. The synthesis also presents prioritized projects to address these issues.

Human Uses

The primary human uses of the different portions of the Kilchis watershed consist of:

- uplands—timber production, recreation, and aggregate mining;
- lowlands—dairy production, residential, aggregate mining, and recreation; and
- estuary—commercial and sport fisheries and shellfish, and other recreation.

Environmental problems related to human uses will be discussed throughout this summary with the exception of the Swiss Needle Cast disease, which is discussed below.

The current Swiss Needle Cast epidemic on Douglas-fir includes all of the TSF and heavily affects the Kilchis watershed. Weather patterns appear to have been a major factor in leading to the current epidemic over the last 10 years, and may have a major effect on the future course of the epidemic. Private companies in the region plan to convert some young Douglas-fir plantations to other species due to projected economic losses from the disease. The TSF is preferentially harvesting Douglas-fir trees and leaving other species during commercial thinning operations. The Swiss Needle Cast epidemic may have major effects on the proposed structure based management plan for the TSF in the coming years.

Hydrology

Formerly the river was tightly connected to its floodplain due to large logjams in the tidal area that reduced the capacity of the river channel to transport flood flows. Every time river flows raised above a moderate level, the river would overflow its banks and spread out through the bottomland forest and other wetland areas. Consequently, the bottomland hardwood forest was flooded for most of every winter, providing ideal habitat for salmonids. The logjams were removed in the late 1800s to facilitate conversion of floodplain lands to agricultural uses.

A number of farm building complexes and some residences have been built in the Kilchis floodplain. These structures are at risk during all overbank flow events, which occur several times each year in the lower Kilchis watershed. In addition to the risk of structural damage, floodwater flowing around the buildings can become contaminated with potentially large quantities of manure, farm chemicals, human waste from on-site septic systems, and other pollutants.

Stream Channels

The majority of the stream channels in the Kilchis Watershed lack adequate structure to provide high quality aquatic habitat. The lack of structure is due to deficient levels of LWD and boulders in the stream channels. The lack of LWD in the channels is due to: the Tillamook Burn, historic logging of riparian areas, salvaging conifer logs from the streams, stream cleaning to remove log jams, limited conifer regeneration in the riparian areas following disturbances, and the predominance of alder in the riparian areas. To increase the potential for conifer LWD in the future, a program of interplanting conifers in alder-dominated riparian is needed throughout the upland forested areas.

Many areas also lack adequate numbers of boulders to provide structure and habitat in the stream channels. This is due partly to the geology of the area and partly to debris flows flushing the boulders out of the smaller channels. It is not feasible or cost effective to place large numbers of boulders in the streams, so this type of habitat enhancement will have to be used very selectively, if at all, in the Kilchis.

Because the stream channels lack structure they are: unable to sort and store spawning gravels, unable to retain and process adequate levels of organic matter, and have inadequate pool area and depth. Currently gravel and organic matter are flushed through the channels too rapidly with a resultant lowering of aquatic habitat quality.

Riparian

The majority of the riparian stands in the Kilchis watershed are in poor or degraded condition; only 14% are rated as good quality on both banks. In the uplands, the primary problems are the lack of conifers and the predominance of alder in riparian stands. The devastated riparian areas primarily revegetated with alders following the Tillamook Burn. Less than 5% of the riparian stands in the Kilchis have adequate numbers of large conifers for providing future LWD to the channels. Alder provides good shading of the channel during the growing season, but no thermal cover in the winter when it has lost its leaves. Alder also provides poor LWD because it is smaller than conifers and decays at a much faster rate. Alder organic matter additions to the channel decay at a faster rate than conifer needles so that they provide adequate fuel for the foodweb for a shorter period of the year than conifers.

Lowland riparian stands are largely absent in the agricultural areas of the Kilchis watershed. The majority of agricultural fields in the Kilchis are former bottomland forest stands. When the fields were cleared, all of the trees were removed up to the banks of the river with isolated exceptions (*e.g.*, few isolated black cottonwoods standing in pastures along the Kilchis). The lowland riparian stands formerly slowed floodwater, stabilized banks, trapped sediment to accumulate the fertile floodplain, provided LWD for instream habitat, supplied organic matter to support the foodweb, and performed other ecosystem functions.

Riparian stands in the Kilchis watershed are currently not providing the following ecosystem functions adequately to maintain quality salmonid habitat: winter thermal cover to keep water warm enough for salmonids, summer shading to keep water cool, long lasting fine organic matter inputs to support the food web, and inadequate LWD potential to provide structure to the aquatic habitat over the long term.

Erosion

Historically, the largest sources of erosion have been forest fires caused by logging operations, timber operations in the uplands and bank erosion in the lowlands. Timber operations include road building and its long term effects, salvage logging operations, and regular harvest operations.

The Tillamook Burn and subsequent salvage logging have had several long lasting effects. These effects include: very high landslide rates, extensive loss of topsoil, widespread destruction of aquatic habitat by the resulting debris flows, widening of stream channels, simplification of plant communities (undocumented), and substantial loss of LWD to salvaging and stream cleaning operations.

The most important type of erosion caused by timber operations and fire effects is shallow, rapid landslides. The former method of road construction that side-cast excess material is responsible for the vast majority of unstable roads that can cause landslides; the current method of end-hauling excess material on side slopes or constructing new roads on ridge tops substantially reduces the risk of landslides from new forest roads. Landslides are very important in providing stream channels with gravel for spawning habitat, organic matter to support the food web, and LWD and boulders to provide structure to the stream channels. The increased incidence of landslides caused by roads and the altered composition of landslides in the Kilchis (*i.e.*, lack of conifer LWD) frequently results in serious degradation of aquatic habitat values.

The second most important type of erosion is road washouts, which can deliver large quantities of fine sediment along with varying levels of coarse sediment and low levels of LWD. The fine sediment is largely flushed through the system if the erosion occurs during high flows, but during normal or low flows this fine sediment can have serious effects on spawning gravels through filling gravel interstices and on pools through filling with sediment.

The current ODF program in the Kilchis to upgrade existing forest roads, decommission legacy roads, and construct new roads to higher standards will reduce road related erosion and help preserve existing habitat values. The erosion of fine sediments from road surfaces due to vehicle traffic will increase over the next decades as thinning and harvest operations increase in the TSF. Increased attention to the quality of rock used on forest roads during the upgrade process would minimize the generation of fine sediment from traffic.

Bank erosion is locally severe in the lowlands, but appears to only be severe in the uplands in association with debris flows. The lowland erosion is due to a combination of factors including deposition of bedload in low gradient reaches, loss of riparian vegetation that formerly stabilized the banks, and cattle access to the stream banks. The lowlands erosion rate per unit of land is equal to or slightly larger than that of the forested uplands, but it is all concentrated on the river banks. Planned measures to revegetate the banks and restrict cattle access to the banks will reduce this source of erosion, but continued high bedload deposition may cause substantial ongoing bank erosion. Instream gravel mining has been suspended due to the decline in the chum salmon population; there is a review pending of the various effects of the mining moratorium.

Water Quality

The most important water quality issues are water temperature throughout the watershed, bacteria contamination in the floodplain and estuary, and multiple water quality problems (*i.e.,* high water temperatures, low dissolved oxygen, high nutrient content) in the sloughs of the lower watershed. Water temperature has been mentioned previously in relation to summer shade and winter thermal cover. In general, temperatures in the upper watershed (North and South Forks), some of the tributaries, and portions of the mainstem in the lower watershed are frequently outside the preferred range for salmonids. In the upper watershed this is due to degraded riparian and alder domination of riparian stands. In the lower watershed it is primarily due to absent or degraded riparian in agricultural areas.

The Kilchis has the lowest bacteria loading of the five rivers in the Tillamook Basin. Bacteria contamination of surface waters is primarily due to overland flow from agricultural fields receiving manure as fertilizer, and to failing on-site septic systems. Two current research projects are attempting to identify the bacteria sources and type them as either cattle, human, or other (the sources will not be identified, but may include wildlife, horses, poultry, etc.). One project uses antibiotic resistance to separate the types of bacteria and the other uses gene sequencing to type the bacteria.

The sloughs have unquantified water quality problems involving bacteria and nutrient loading, inadequate water exchange and flushing, elevated water temperatures in summer, and low dissolved oxygen in summer. Because the sloughs were important historically as salmonid rearing habitat, these water quality problems need to be addressed in any attempt to restore salmonid populations in the Tillamook Basin. Measures to address the degraded slough habitat would include: reducing bacteria and nutrient inputs through implementing best management practices on dairies, replacing failed septic systems, improving water exchange through replacing or removing tidegates, increasing flushing from winter high flows through reversing hydrologic modifications, and restoring riparian stands to provide shading and LWD.

Wetlands

Wetlands in the upland forested areas primarily consisted of riparian, and spring and seep wetlands. The spring and seep wetlands are small, scattered through the forest and there are no indications that they have been heavily impacted. Wetlands in the lowlands formerly consisted of bottomland hardwood forest, seasonally ponded areas, freshwater emergent marsh, brackish tidal marshes along sloughs and river channels, and tidal salt marshes adjacent to the bay. The vast majority of these wetlands (approximately 86% in the Tillamook Basin lowlands) have been converted to agricultural use or developments. In the lowest elevation areas the conversion was not completely successful and native wetland flora persist (*e.g.* Juncus, Salix, etc.).

Many of the wetlands (bottomland hardwood forests, seasonally ponded areas, emergent marshes, tidal marshes) in the lower Kilchis were highly productive off-channel habitat for salmonids and contributed to the former high productivity of the Kilchis for salmonid species. The off-channel habitat allowed the fish to escape high flows, utilize abundant food resources, and prepare for the transition to salt water and for ocean survival. The loss of these areas has had a large impact on the overall productivity of the Kilchis for salmonids.

Estuary

The estuary is an integrator of inputs from all over the watershed including water, sediment, chemical, biological, and atmospheric inputs. The estuary has input into upstream areas through the return of anadromous fish, storm surges that raise bay levels and back up rivers exacerbating flooding impacts, moderation of high and low temperatures in the basin, and other effects.

The estuary has been drastically changed from its prehistoric condition through human uses and indirect effects. The estuary formerly had a complex habitat structure with a wide range of depths, different types of cover, complex channel patterns, a larger tidal prism, diverse biotic communities, and a range of substrate types. The direct human changes include:

- removal of large quantities of LWD, which caused loss of associated scour holes and other forms of habitat structure, and loss of associated plant and animal communities;
- construction of pile dikes to concentrate water flows into two main channels, which caused the siltation of some channels and kept others flushed out;
- diking and draining, or filling of tidal lands for such purposes as agricultural use, road, marina, and industrial construction, and repair of the Bayocean Spit breach, which caused loss of habitat valuable for salmonid rearing, migrating birds, and other wildlife;
- dredging to deepen shipping channels and alleviate flooding, which caused short-term habitat loss and longer term hydrologic changes;
- jetty construction to make the mouth safer for navigation, which caused changes in currents and may have made it more difficult for crabs to enter the bay;
- loss of various fish species due to extensive habitat changes and/or overfishing, which alters community composition and ecological balances;

- massive sedimentation from the Tillamook Burn and salvage logging, the spit breach, other road building and logging operations, agricultural clearing of riparian areas, development activities, and other sources, which has drastically changed the bathymetry of the bay with many ecological ramifications;
- major species shifts due to reductions in the salmonid and other commercial fish populations, which alters ecological balances including nutrient cycling and predator/prey relations; and
- the introduction of commercial non-native oyster production, which has probably impacted eelgrass populations, and reduced habitat for some native species while favoring others.

The sum of the human-induced changes is cumulative and results in a vastly simplified estuary. The simplification includes:

- reduced numbers of species;
- simpler community composition;
- fewer, shallower and less complex channels;
- structurally less complex and much reduced intertidal and tidal areas;
- greatly reduced tidal prism;
- very little LWD and no islands at high tide;
- greatly reduced energy and nutrient transfer back to the watershed (fewer anadromous fish); and
- smaller total acreage.

Fish and Wildlife

Salmon populations are depressed and in several cases are heavily supported by hatchery releases. The single exception is fall chinook, which is considered healthy and is either stable or increasing. The impacted salmonid populations are due to the interaction of a number of factors including heavy impacts on upland habitat, destruction or heavy degradation of lowland habitat, simplification and other degradations to estuary habitat, overfishing, and periodically poor ocean conditions.

Channel modifications in the Kilchis affecting salmonid habitat include: stream cleaning of LWD, installation of riprap, loss of riparian communities, impacts from bridge and road construction, OHV crossings and erosion, debris flows, improperly placed culverts, and channelization.

Although there are many threatened or endangered species in Tillamook county, there is no specific information for the Kilchis Watershed on these species. A list of wildlife species residing in the Kilchis watershed was compiled from species range maps.

Summary

The Kilchis Watershed has been heavily altered from its pristine state through human activities over the last 140 years. Prior to that time Native Americans primarily altered the landscape through periodic burning to enhance food production and to reduce brush.

The forested uplands have been altered through logging of mixed old growth stands and conversion to largely monotypic second growth stands. Swiss Needle Cast is threatening monotypic stands of Douglas-fir with loss of vigor, increased susceptibility to insect attack, and competition from other vegetation. Landslide rates are higher than the natural background levels and the landslide material reaching streams contains insufficient large woody debris. Stream channels were "cleaned" of LWD and lack structure for habitat and sediment retention.

The lowlands have been altered through conversion to agriculture and various forms of development. Agricultural conversion has resulted in very simple grass communities on areas that formerly supported a diverse mosaic of wetland types. Runoff from agricultural areas carries bacteria and nutrients into surface waters, and cattle access to streambanks results in loss of riparian vegetation, increased bank erosion, disturbance of chum spawning habitat, and direct water contamination. Urban and industrial development has resulted in many structures located on floodplains that: impede floodwater, increase runoff from impervious surfaces, contaminate storm runoff with chemicals and nutrients, and converted native communities to landscaping. Road construction has resulted in major hydrologic changes, fragmented habitat, filling of sensitive habitats, and contaminated runoff routed directly to stream channels.

The estuary has been altered through dredging, diking, draining, filling, jetty construction, sedimentation, removal of LWD, loss of many species, impacts to eelgrass, and fishing impacts.

The overall effect of these impacts across the watershed has been a simplification of habitats and the biotic communities that they support. In order to help populations of fish, wildlife and plant species recover, some conservation and restoration activities need to take place. These activities (in order of importance) are:

- increase the protection of existing high quality habitat such as salmonid core areas (includes erosion control and landslide reduction efforts in the adjacent uplands), the riparian forest on Squeedunk Slough, and the pristine saltmarsh that has recently accreted;
- restore the riparian vegetative corridor along the floodplain portion of the mainstem;
- restore the instream habitat structure and sediment storage capacity through the addition of LWD and boulders in the areas listed in the report;
- restore LWD to the tidal portions of the mainstem and sloughs to provide cover and habitat structure;
- restore the habitat quality in the sloughs through hydrologic reconnection, adding LWD, and modifying tidegates; and
- interplant conifers in upland riparian forests dominated by alder.

If the conservation and restoration actions listed above are implemented over the long term, then there will be an increase in high quality habitat for salmonids and their populations will have the chance to recover. Numerous other aquatic species would also benefit from the same actions and would help to maintain the diversity of the biotic communities of the Kilchis Watershed.

1.0 The Setting: Characteristics and Land Use in the Tillamook Basin[2]

Introduction

The Kilchis Working Group (KWG) consists of staff from the Tillamook Bay National Estuary Project (TBNEP) and representatives of many local governmental agencies; the contributors are listed on the page following the title page of this report. This analysis was performed for two reasons: 1) the KWG needed a way to focus and synthesize the results of applied research on the condition and trends of natural resources, and the factors affecting those resources; and 2) a detailed watershed analysis was needed to supplement watershed assessments planned for the region.

The KWG chose a watershed analysis as the best approach for synthesizing the results of the applied research on natural resources. The KWG also developed a citizen-based watershed assessment manual for coastal Oregon as a parallel effort. This analysis uses the same structure as the assessment manual although the analysis uses greater depth and detail than the assessment calls for. The assessment manual and this analysis had the following areas of emphasis: human uses, erosion, stream channel, riparian, hydrology, water quality, wetland, estuary, fish and wildlife, and synthesis. Sets of questions for each area of emphasis regarding the effects of human activities and natural processes on resources were then used to synthesize the information.

This analysis is intended to serve as a regional model for surrounding watersheds with similar geology, climate, soils, topography, natural resources, human uses, and environmental problems. Assessments conducted on the surrounding watersheds can be correlated to this detailed analysis to yield greater understanding of each system and its problems. Thus, government agencies and citizen groups can learn more about their respective watersheds using relatively low-cost watershed assessments.

The Kilchis Watershed (Figure 1-1 and Table 1-1) was chosen because it is representative of the other watersheds in Tillamook County and the North Coast region. The area this analysis is representative of stretches from the Nehalem River in the north through the five rivers of the Tillamook Basin (Miami, Kilchis, Wilson, Trask, and Tillamook) to the Big and Little Nestucca Rivers to the south. The Kilchis Watershed is comparable in land uses to the rest of the Tillamook Basin as shown in the following table.

[2] Text for this chapter was largely taken from TBNEP (1997).

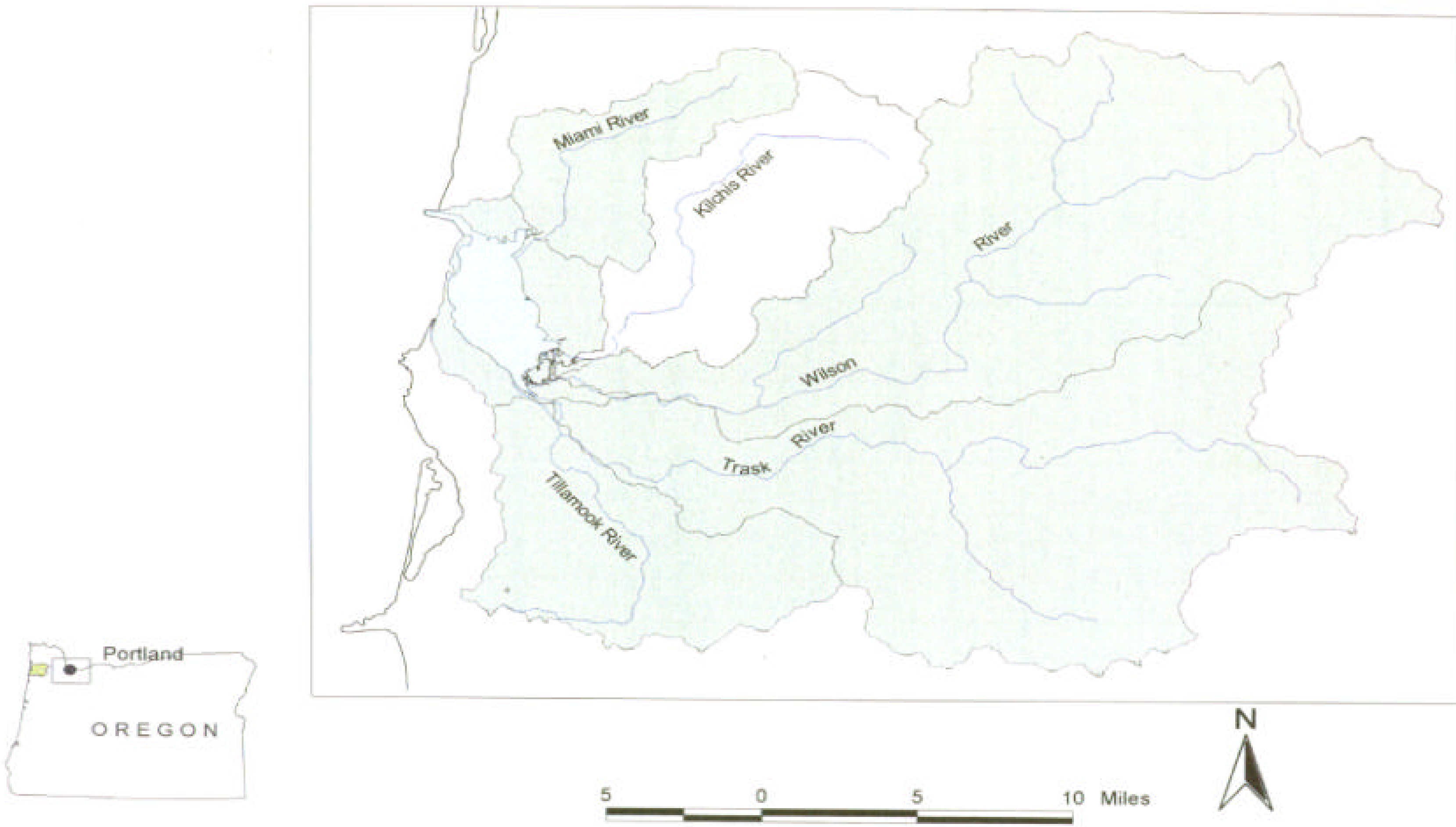


Figure 1-1. The Tillamook Bay watershed is a coastal watershed located in northwestern Oregon. (Source: TBNEP GIS layer TILLSUB)

Table 1-1. Area of land in the Tillamook Basin and Kilchis Watershed by Use Category

	Tillamook Basin	Kilchis Watershed
Total Area	364,800 acres (147,692 hectares)	46,920 acres (18,768 hectares)
Forest Land	324,672 acres 89%	43,166 acres 92%
Agriculture	23,712 acres 6.5%	2,760 acres 5.8%
Urban/Rural Development	5,472 acres 1.5%	140 acres 0.3%
Rivers, Streams and Estuary	10,944 acres 3% (includes Bay)	280 acres 0.6%

Source: Oregon Department of Environmental Quality. 1992. The nomination of Tillamook Bay, Oregon to the National Estuary Program. Prepared for the State of Oregon, Barbara Roberts, Governor, Salem, OR. Tillamook Bay Task Force. 1978. Tillamook Bay Drainage Basin Erosion and Sediment Study.

Regional Setting

The regional setting of the Kilchis Watershed within Tillamook County and Oregon helps in understanding the basic human and natural resources of the watershed. The topics in this section are: human population, climate, geology, topography, soils, and vegetation.

Human Population

Since 1950, the population of Oregon has doubled and Tillamook County's population has increased by approximately 20% to 23,300 in 1995. Population growth in Oregon, especially Tillamook County, historically depended on fluctuations in the natural resource industries. In recent years, population growth has been less a reaction to natural resource industries and more a function of living conditions and quality of life concerns. Although Tillamook County's population has continued to grow, birth rates have decreased and death rates have increased since 1990 (Center for Population Research and Census 1997). Population growth can be attributed primarily to in-migration, which is expected to continue to increase.

Climate

The Tillamook Basin is part of a coastal, temperate rainforest ecosystem. Mean annual precipitation is around 100 inches, mostly in the form of rain, but also snow in the higher elevations. In 1996, however, 126 inches of lowland rain (and very heavy upland rain and snow) led to severe flooding throughout the Basin and caused significant economic and environmental damages. From 1961 through 1990, The City of Tillamook averaged 90 inches of rain per year with 76% of total precipitation occurring from October through March. The highest precipitation and rainfall events occurred during November, December, and January. Tillamook County averaged more than 23 days per year in which precipitation exceeded 1 inch.

The mean annual temperature is 50.4^{o}F, with yearly mean maximum and mean minimum temperatures documented at 59.3^{o}F and 41.6^{o}F respectively. The 30-year average was less than one day per year with a temperature over 90^{o}F. September had the greatest number of extreme temperatures while July and August recorded the highest temperature of 102^{o}F.

Geology

Indurated rock units of Tertiary age and unconsolidated deposits of Quaternary age underlie the basin. The consolidated rocks called the Tillamook Volcanics and associated submarine facies include basalt and basaltic andesite flows, breccia, dacite, marine siltstone and sandstone, and intrusive rocks (Wells *et al.* 1983). These rocks are generally fine grained and poorly permeable, but porous zones do exist where the rock is fractured. The unconsolidated Quarternary age deposits are composed of sand, gravel, and silt from alluvial deposition and sand from ocean and wind deposition. The alluvial fan of the Kilchis River begins at about River Mile 5. From this point on, the river valley gradually widens and coalesces with the coastal plain. Well logs for City wells in nearby Tillamook show coastal plain alluvium to be from 128 to 200 feet deep in the area of the City. Wells in the alluvium can yield generous quantities of water. The well logs for the City of Tillamook show yields ranging from 58 to 920 gallons per minute (gpm). With respect to hydrogeology, the makeup of the Kilchis Basin varies little from the other four major stream basins in the greater Tillamook Basin.

Topography

The Tillamook Basin is situated in typical Pacific Northwest coastal terrain. A relatively straight coastline consists of miles of sandy beaches punctuated with cliffs of igneous rock and small inlets such as Tillamook Bay. Except for the lower alluvial fan of the Kilchis Basin extending to Tillamook Bay, the Basin has steep terrain. Along with the alluvium deposited by the other four major rivers of the Tillamook Basin, the Kilchis alluvial fan merges into a wide coastal plain separating the coast from the mountains. This wide flat plain forms the lower part of the basin and represents roughly about 5–8 % of the total Kilchis Basin. The highest part of the basin is at Triangulation Point at an elevation of 3,294 ft, on the Kilchis-Nehalem Basin boundary. With respect to topography, the makeup of the Kilchis Basin varies little from the other four major stream basins in the greater Tillamook Basin.

Soils

Upland areas consist mostly of volcanic basalt base material with overlying soils formed from basalt, shale, and sandstone. Primarily an Astoria-Hembre association, moderately deep upland soils cover the gently sloping terrain and very shallow soils cover the very steep terrain of the forested uplands. The soils in the spruce zone (see the following section for definitions of vegetation zones) are deep (except on steep slopes where they are shallow), fine textured, typically acid (pH 5.0 to 5.5) and high in organic matter (15–20%). The soils in the hemlock zone are derived from sedimentary and basalt parent materials, of moderate depth (except on steep slopes where they are shallow) and medium acidity, with a high infiltration rate.

In the Tillamook Basin, five river valleys dissect the steep slopes of the uplands and bring sediment and organic material to the rich alluvial plain and estuary below. In this setting, a discontinuous coastal plain separates the coast and the mountains. Derived from basalt and sandstone-shale bedrock, these deep, level floodplain soils have been deposited over thousands of years by the streams and rivers. They range in width from a few hundred feet to more than a mile and can extend upstream up to seven miles along broad stream channels. Known as the Nehalem-Brenner-Coquille association, these are among the most fertile soils in the area, but require drainage for maximum productivity. Originally, these soils were almost all forested; but most have been cleared and are used for hay and pasture. Most farmers irrigate their soils in the dry summer months. Between the bottom-land floodplain and the forested regions, extensive alluvial terraces extend up to 80 feet. Referred to as the Quillayute-Knappa-Hebo association, these soils have high to medium organic content, but are less fertile than soils on the bottom lands. Alluvial terrace soils make up about 50% of the Tillamook Basin's tillable lands (Franklin and Dyrness 1973).

Vegetation

A series of forest fires (1933, 1939, 1945, 1951) burned much of the natural vegetation of the upland forests. Today, most of the mixed conifer upland forests have been replanted in Douglas fir trees; these plantations are in the 26-50 age class in Figure 1-2. The natural vegetation of the Tillamook Basin is evenly distributed between the Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) vegetation zones. These two vegetation zones extend from British Columbia to northern California, running roughly parallel to the coast, with the hemlock zone also enclosing the Willamette Valley (Franklin and Dyrness 1973).

The spruce zone covers the lower regions of the Watershed and normally occurs at elevations below 450 feet (150 meters). It is a wet zone with the nearby ocean adding frequent summer fogs and moisture to otherwise dry months which distinguishes the spruce zone from the higher elevation hemlock zone. Dense, tall stands of Sitka spruce, western hemlock, western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), and grand fir (*Abies grandis*) dominate the spruce zone. In dune areas close to the ocean, shore pine (*Pinus contorta contorta*) is locally common. Hardwood species occurring in the zone include red alder (*Alnus rubra*), and bigleaf maple (*Acer macrophyllum*), with red alder dominating recently disturbed sites and some riparian areas. Understory vegetation is generally composed of a dense growth of shrubs, herbs, ferns and cryptograms. Common native species include sword fern (*Polystichum munitum*), wood sorrel (*Oxalis oregona*), evergreen and red huckleberry (*Vaccinium ovatum* and *V. parvifolium*), salal (*Gaultheria shallon*), red elderberry (*Sambucus racemosa*), and western rhododendron (*Rhododendron macrophyllum*).

Successional patterns in the spruce zone following fire or logging are often dominated by a dense shrub community composed of salmonberry (*Rubus spectabilis*), sword fern, elderberry, and huckleberry, with the relative dominance varying with the site conditions. The shrub community can persist for quite some time due to the excellent growing conditions, but at some point it yields to one of two types of seral forest stands. The conifer type is a mixture of spruce, hemlock, and Douglas fir and the hardwood type is a monotypic, dense stand of red alder. Replacement of the alder stands can be very slow, due to the dense shrub understory. The resulting communities are either semipermanent brush fields, spruce stands, or red cedar and hemlock that grew on downed logs. This is the natural successional pattern, but on managed lands there is a mosaic of pure conifer stands due to past reforestation and alder stands due to human disturbance.

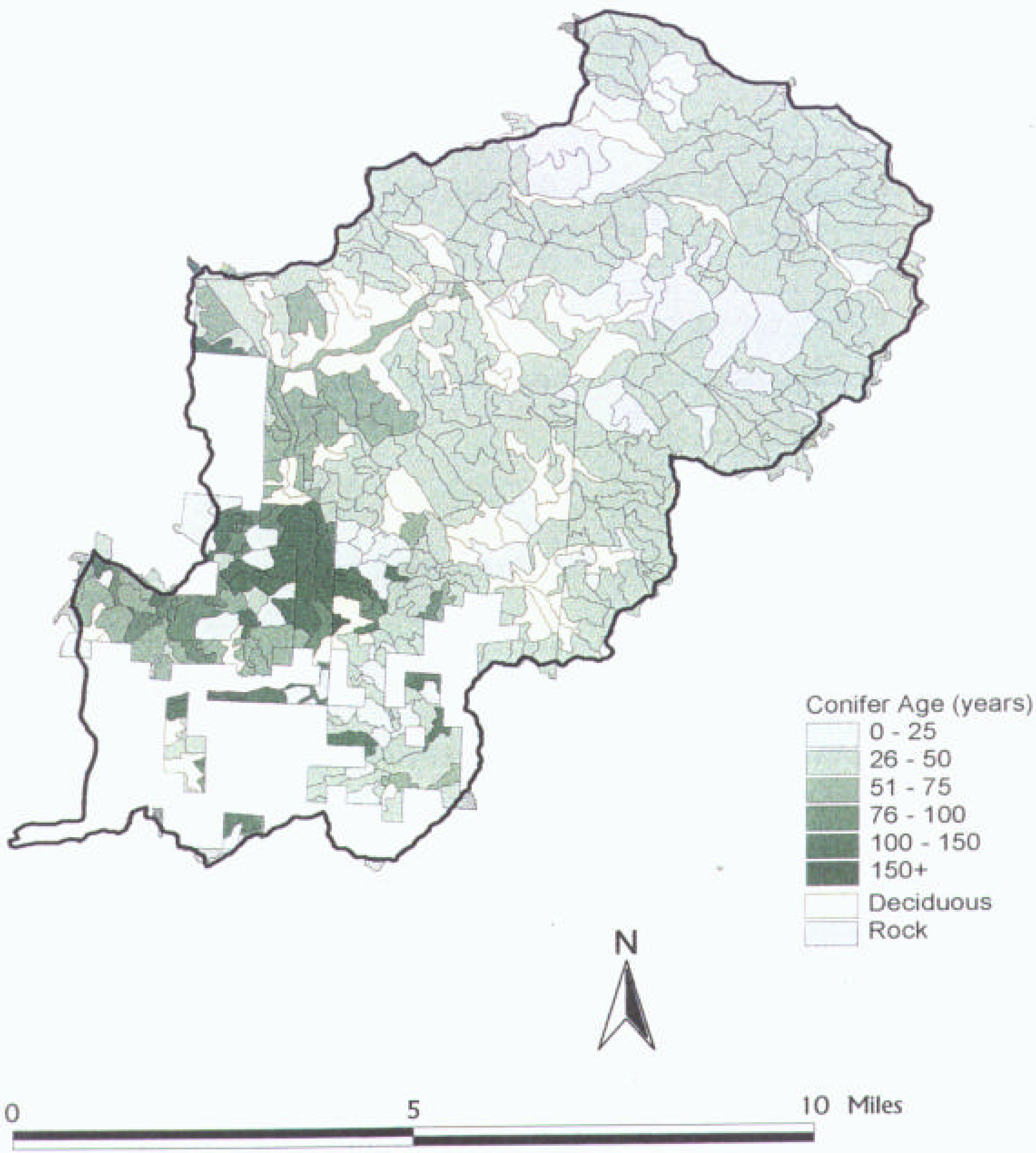


Figure 1-2. Age of forest stands in the Kilchis watershed in 1996. (Source: TBNEP GIS layer TILVEG)

The hemlock zone normally extends in elevation between 450 feet (150 meters [m]) and the subalpine zone of the Coast Range. With less ocean influence and summer fog, the upland hemlock zone still receives heavy precipitation. In the hemlock zone the dominant vegetation is dense conifer forest. Forest stands are dominated by Douglas fir, western hemlock, and western red cedar, with other conifers mixed in, such as grand fir, Sitka spruce, and Pacific yew (*Taxus brevifolia*). Hardwood species occurring in the hemlock zone include red alder, bigleaf maple, black cottonwood (*Populus trichocarpa*), and Oregon ash (*Fraxinus latifolia*). Understory vegetation varies with moisture regimes, but in the moist coastal portion of the hemlock zone, sword fern, wood sorrel, rhododendron, vine maple (*Acer circinatum*), and Oregon grape (*Mahonia nervosa*) are the most common species.

Successional patterns in the hemlock zone following fire or clearcut logging bring the first year residual species and invading herbaceous species from the genera *Senecio* and *Epilobium*. This community is replaced during years two to five by one dominated by fireweed (*Epilobium angustifolium*), thistle (*Cirsium vulgare*), and bracken fern (*Pteridium aquilinum*). The next community is dominated by shrubs such as vine maple, Oregon grape, rhododendron, salal, and blackberry species (*Rubus* spp.). Eventually the shrubs are overtopped by conifers such as Douglas fir.

Land Ownership and Human Uses of the Kilchis Watershed

Land ownership and human uses affect how and to what extent natural resources are utilized. Other pieces of this picture are zoning, roads and mining activities.

Maps of Land Ownership and Human Uses

Figure 1-3 shows the land ownership in Tillamook County, Figure 1-4 shows the land use zoning for the county, Figure 1-5 shows all roads in the county, and Figure 1-6 shows the location of mining activity within the county.

Uplands

The forested lands in Tillamook County have provided timber harvest for wood products industries since the 1880s. While the extensive stands of timber were originally viewed as a hindrance to farming, by 1894 the timber industry was considered the County’s most important industry (Levesque 1985). As demand for timber products increased and technology evolved, the number of timber workers and amount of harvested timber increased dramatically. Through the Donation Land Act of 1850, the Homestead Act of 1862, and the Timber and Stone Act of 1878, private timber companies acquired much of the County’s valuable timber (Levesque 1985). Large scale logging began in the early 1900s with no effort to reforest cleared lands.

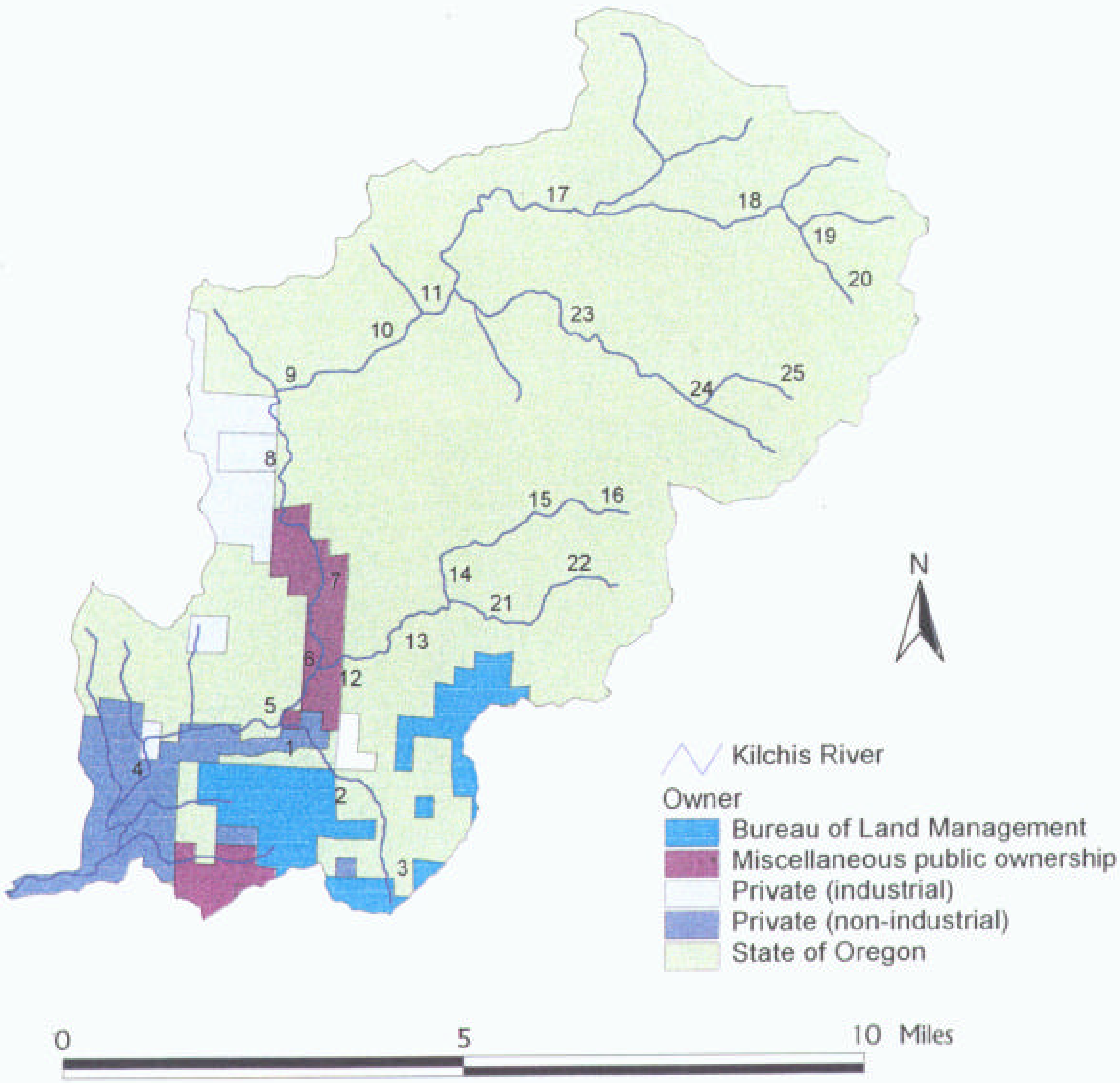


Figure 1-3. Land ownership in the Kilchis watershed. (Source: TBNEP GIS layer OWNER)

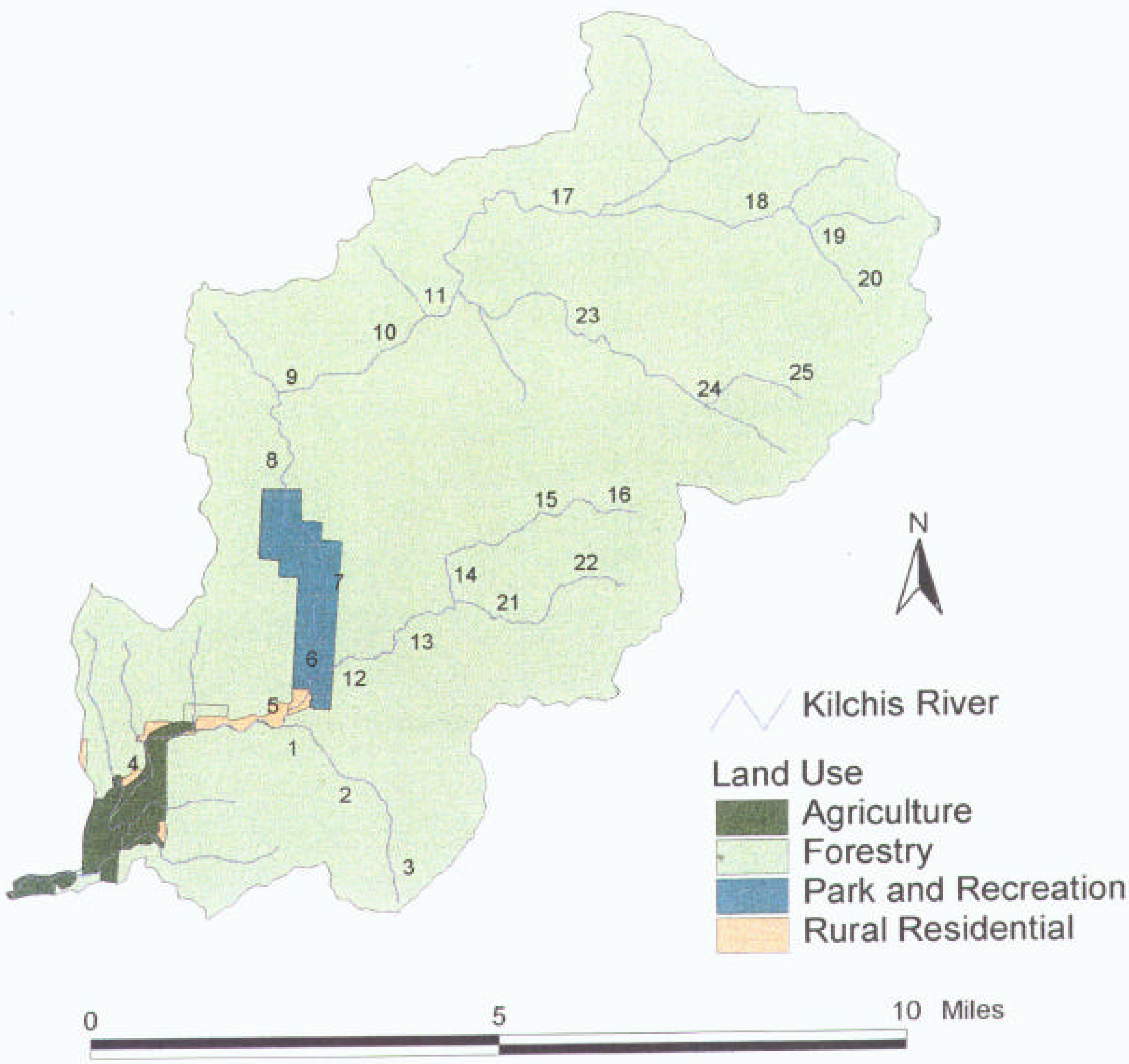


Figure 1-4. General land use classification for the Kilchis watershed. (Source: SSCGIS GIS layer ZONING)

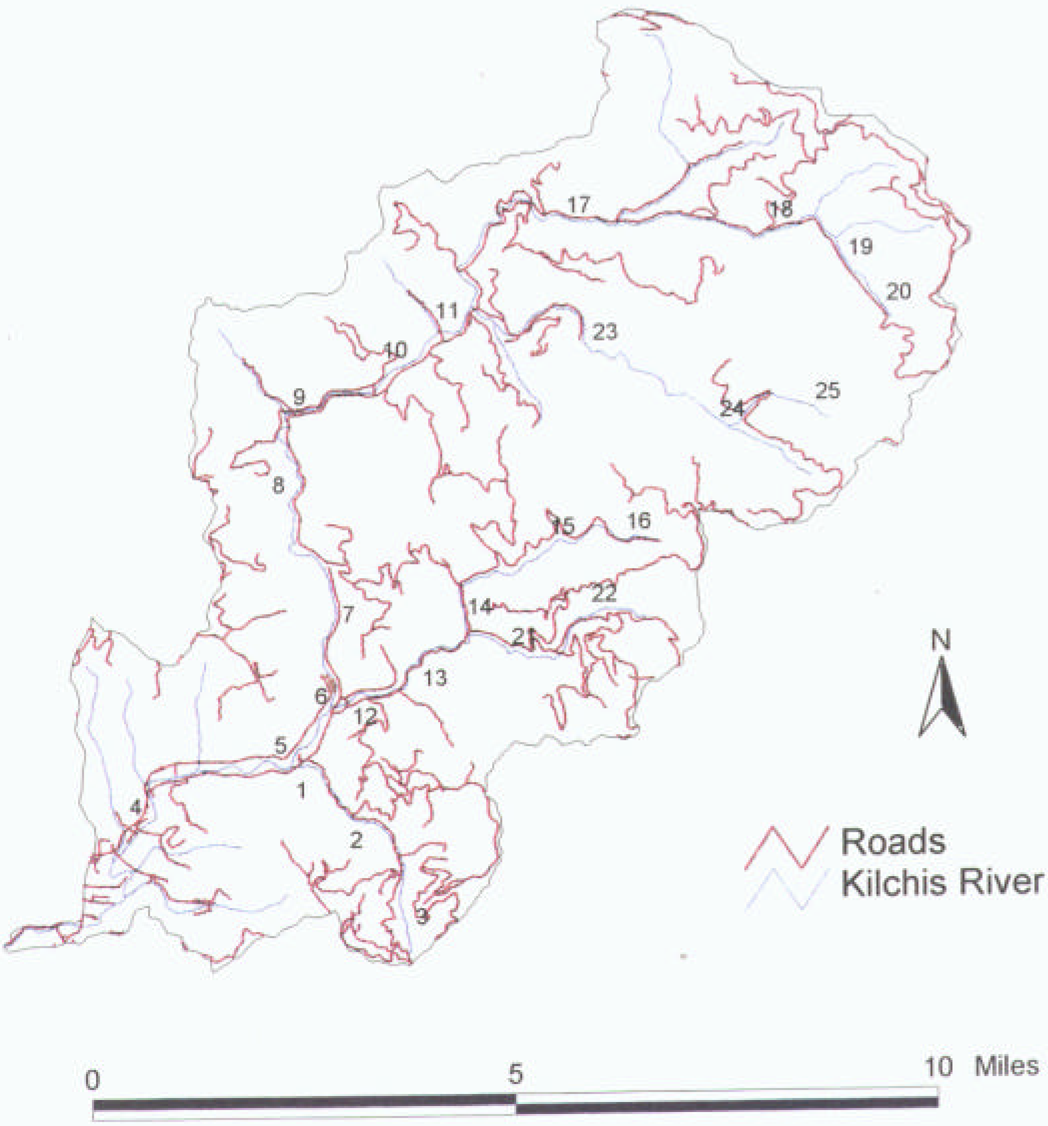


Figure 1-5. Roads in the Kilchis watershed. (Source: TBNEP GIS layer RDALL)

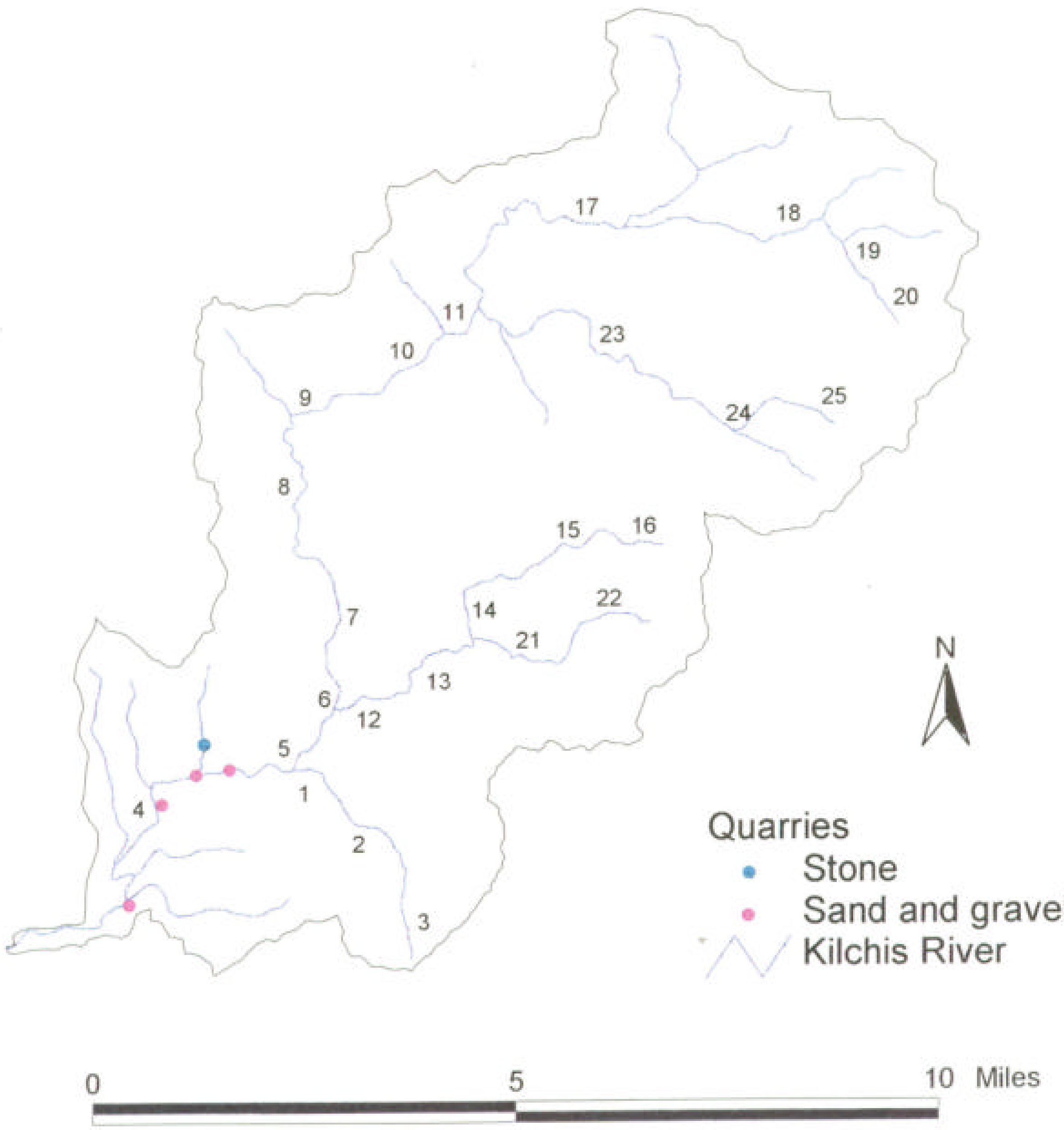


Figure 1-6. Stone, sand, and gravel quarries in the Kilchis watershed. (Source: TBNEP GIS layers TILSGRAV, TILSTON)

The Cedar Butte fire burned portions of the Kilchis Watershed in 1918. The Tillamook Burn, a series of forest fires occurring in 1933, 1939, 1945 and 1951, profoundly affected the use of forest lands in the region. The fires killed most (about 200,000 acres) of the old-growth timber in the Kilchis, Wilson, and Trask River watersheds, burning some areas up to four times. The fires were followed by road building for salvage logging, fire protection and replanting (Levesque 1985). Reforestation of the burned acreage began in 1949. Since salvage logging ended in 1959, timber harvest in the Tillamook Burn area, now the Tillamook State Forest (TSF), has been mainly commercial thinning. However, remaining private timber lands have been intensively clear-cut in recent years (Labhart, M. personal communication 1997).

Currently, timber production is the primary use of almost all of the forested upland. The timber products industry generated 11% ($37 million) of Tillamook County personal income in 1993 (Radtke 1995). In Tillamook County, forest land ownership is 46% State, 23% private industrial forest lands, 14% U.S. Forest Service, and 8% Bureau of Land Management (ODF 1995). The remaining 9% of forest lands are owned by private small woodlot or other public owners.

Lowlands

Early settlers came to Tillamook beginning in 1851 primarily to farm and they recognized the rich agricultural potential of the lowlands. Within 30 years of the initial settlement, much of the lowland forest was cleared, diked, and drained to increase the amount of land available for agriculture. A significant portion of the lower intertidal and freshwater wetland areas was converted to pasture by the early 1900s (Coulton *et al*. 1996). By 1900, Tillamook County had one of the highest numbers of owner-operated farms in the State. The Tillamook County Creamery Association (TCCA) was established in 1909 as a cooperative of 10 smaller cheese producing cooperatives (Schild, H. personal communication 1997).

Today the rich alluvial plains are used primarily for dairy agriculture. Dairy products generated 82% of the County’s agricultural income in 1995. The only other major agricultural commodities in the County were small woodlots, and cattle and calves, which generated 11% and 5% of the total income, respectively (Oregon State University [OSU] Economic Information Office 1996). Once characterized by meandering rivers and networks of small channels that provided fish habitat, woody debris, and organic matter (Coulton *et al.* 1996); today's 40 mi^2 of lowland supports about 28,000 dairy cattle and produces 95% of Oregon’s cheese. Cattle also produce approximately 2.37 million pounds of manure and 0.82 million pounds of urine daily, which contribute to the pollution of surface waters. Dairy farms are regulated by the Oregon Department of Agriculture through the Confined animal Feeding operation (CAFO) permit system. The permits system helps regulate the number of cows allowed in an operation, the manure storage and handling practices, and other farming practices that could have an impact on environmental values both on and downstream of the farm.

Estuary

Tillamook Bay is a small, shallow estuary about 60 miles west of Portland on the Oregon Coast. Approximately 6.2 miles long and 2.1 miles wide, the Bay averages only 6.6 feet in depth over a total area of 13 mi^2, or 8,400 acres. At low tide, about 50% of the Estuary bottom is exposed as intertidal mud flats and the rest is made up of winding channels. Tillamook Bay is a drowned river canyon so these deep channels, running roughly north-south, represent the geologic signatures of river mouths drowned by the rising Pacific Ocean about 9,000 years ago. The Bay receives fresh water input from five rivers and exchanges ocean water through a single channel in the Northwest corner. Despite large freshwater inflows, especially during the rainy winter months, heavy tidal fluxes dominate the system; extreme diurnal tides can reach 13.5 ft (4.1m), with a mean tidal range of 5.6 ft (1.7m) and diurnal range of 7.5 feet (2.3m). Tidal effects extend various distances up the rivers, ranging from 0.4 miles (0.6 km) for the Miami River, to 6.8 miles (11 km) for the Tillamook River (Komar 1997). The volume of water entering the Bay due to tides has been estimated at 1.63×10^9 cubic feet (4.63×10^7 cubic meters) (Perch *et al.* 1974). The Bay experiences the full range of estuarine circulation patterns, from well-stratified to well-mixed, depending on the season and variations in river discharge. During heavy rain in winter months (November through March), researchers describe a stratified system, but during low precipitation summer months the Bay shifts to a well-mixed estuarine system (Camber 1997). Salinity ranges from around 32 ppt near the ocean entrance to around 25 ppt at the upper (southern) end of the Bay near the river mouths. Water temperature ranges from around 47–66^{o}F (8–19^{o}C) over the year.

Due to the treacherous nature of the entrance bar, considered by some to have been the most dangerous in Oregon, the COE constructed the north jetty between 1914 and 1918, and the south jetty was constructed between 1969 and 1974. Serious erosion of the Bayocean Spit was correlated with the construction of the north jetty and many local residents feel that the north jetty caused erosion and the breaching of the spit in 1952. The north jetty definitely caused the accretion of significant dune acreage on its north side at Barview. Since the construction of the south jetty, significant dune accretion has occurred on the west side of Kincheloe Point. The Bayocean Spit appears to be stabilized based on the recent dune accretion and the COE dike construction to close the breach.

Fish and shellfish were historically plentiful in Tillamook Bay and it did not take long for residents to begin a commercial fishing industry. A small export fish cannery was constructed in Hobsonville in 1885 and its products were shipped to San Francisco (Coulton *et al*. 1996). Commercial gillnet fishing in the Bay began in the late 1800s. The large historic populations of chinook, coho, and chum salmon in the basin have been well documented; they are discussed in the Fish and Wildlife chapter. Commercial fishing of coho salmon was regulated as early as 1892. Due to concern over declining salmon populations, fish hatcheries were established in the early 1900s, with the current Trask River hatchery in operation since 1914 (Coulton *et al.* 1996). In 1961, the gillnet fishery in Tillamook Bay was closed, and commercial salmon fisheries moved to sea (Tillamook System Coho Task Force 1995). Tillamook Bay continues to support a thriving charter fishing service, with paid guides hosting recreational anglers. Despite harvest restrictions on an increasing number of species, processing of seafood and fish products has remained a local industry. The Port of Garibaldi provides anchorage, services, and seafood processing facilities for commercial fishing boats, which harvest a variety of species, including salmon, bottomfish, tuna, shrimp, and crab.

Historic information on the shellfish industry in Tillamook Bay is limited prior to the 1960s because harvests were rarely documented. Oysters (*Crassostrea gigas*) are not native to Tillamook Bay, but were first planted in the Bay in 1928. Conditions in Tillamook Bay were formerly very good for oysters and by the early 1970s nearly 90% of Oregon's oysters were grown in Tillamook Bay (US Army Corps of Engineers [COE] 1972). The Bay has long been a major clam producer, harvesting an increasing share of the State's total since the mid-1980s (Johnson, J. personal communication 1998).

Environmental Problems Related to Human Uses

A range of environmental problems in the watershed are related to human uses. These include:

- decline in salmon populations and impacts to salmonid habitats,
- high levels of sediment generation in the forested uplands and intensively used lowlands of the watershed,
- bacteria contamination of surface waters,
- flooding in the agricultural and residential portions of the lowlands,
- an epidemic of Swiss Needle Cast affecting Douglas-fir, and
- flooding in the Tillamook Bay area.

The decline in salmon populations is discussed in the fish and wildlife chapter. The impacts to salmonid habitats and their causes are discussed in the following chapters:

- Stream Channel (large woody debris, boulders, debris flows, bank erosion, fine sediments, and gravel harvest);
- Riparian (riparian stands, stream shading, and potential for large woody debris);
- Water Quality (water temperature); and
- Estuary (estuary habitat and eelgrass).

Sediment sources, mechanisms of channel delivery, and the downstream effects of the sediment are discussed in the following chapters:

- Erosion (timing, delivery and volume of sediment, landslides, road use, and abandoned roads);
- Stream Channel (debris flows, bank erosion, fine sediments, gravel extraction, and channel widening); and
- Estuary (bathymetry and human alterations).

The high levels of bacterial contamination of surface waters are discussed in the following chapters:

- Water Quality (bacteria contamination); and
- Estuary (shellfish).

Swiss Needle Cast

Swiss Needle Cast (*Phaeocryptopus gaeumannii*) is an endemic, chronic fungal disease of Douglas-fir. The epidemic is centered on approximately 400,000 acres west of the crest of the Coast Range including major portions of the TSF. The fungus spores land on the new needles in the spring and send a hyphae in through a stomatal opening on the bottom side of the needle. After a colonization period the fungus grows a spore body out the stomata and releases spores timed to be distributed during the "candling" period when new needles are developing. The fungus causes the loss of photosynthetic efficiency (lowers food production) for the tree thus reducing growth severely in heavily infected trees. The fungus does not directly kill trees, but it does render heavily infected trees uneconomical in a forestry plantation situation.

Since the fungus is an endemic species it has been here for thousands of years, but at a level that caused no known serious losses to the forest. Recently the disease has achieved epidemic proportions both in the number of trees infected and the severity of infections. Previously, the most severe infections were seen in young trees and resulted in slow growth and establishment/weed competition problems. Severe infections resulting in substantially reduced growth (severe—approximately 40% reduction, moderate—approximately 20% reduction) are now found in all genetic sources and age classes of trees in the TSF (Kavanaugh, K. personal communication 1997). The patches of heavy and light infection are found throughout the TSF; Figure 1-7 depicts the extent of the disease in May 1996, and Figure 1-8 depicts the extent of the disease in May 1997. In 1996 for the Tillamook Basin, for all ages there were 1574 acres of high defoliation, 672 acres of medium defoliation, and 1290 acres of low defoliation. In 1997 for the Tillamook Basin, there were 59,233 acres of high defoliation, 73,440 acres of low defoliation. These figures indicate a 3763% increase in high levels of defoliation, and a 5693% increase in low levels of defoliation in one year for the Basin. A similar increase was projected for the May 1998 survey, but the timing of the survey appears to have missed the peak "exhibition" of the disease. The resulting 1998 map shows an apparent substantial decrease in the extent of the disease (Dutton, S. personal communication 1998).

It is not known why the fungus is now infecting such a broad range of genetic sources and age classes over such a large geographic area compared to its former extent, or why it is spreading so rapidly. One theory is that climatic conditions favorable to the disease coupled with the establishment of a large monoculture of Douglas fir with many non-local seed sources led to a high rate of infection in the non-adapted trees. This widespread infection then produced an immense spore load that allowed the fungus to overcome the defenses of the local, disease-adapted trees and infect them as well. A competing theory is that the fungus has mutated and produced a more virulent strain. These theories and others, as well as aspects of the infection cycle, physiologic effects of the disease on the trees, alternative control measures for the disease, and the life cycle of the fungus are being actively researched by the Swiss Needle Cast Cooperative.

The widespread infection of large numbers of trees of all age classes affects the profitability of forest operations as well as their long term management. The Weyerhaeuser Corporation is reported to be converting young Douglas-fir plantations to other species (Kavanaugh, K. personal communication 1997). Because the TSF is essentially a Douglas-fir monoculture, the disease could have far reaching effects on the structure based management plans for the forest. The ODF foresters have already started planting more hemlock, western redcedar and Sitka spruce following harvest operations because of the disease and other considerations.

Flooding

The impacts of flooding are not specifically addressed in this report. In general they include: deposition of sediment and debris on agricultural fields, damage to fencing, damage to structures in the floodplain, disease and mortality of livestock, road closures, increased bacterial and toxic contamination of surface waters, and increased potential for diseases among humans.

There are several types of flood situations in low lying areas of the Kilchis Watershed and the Tillamook Basin. They can result from tides, heavy rainfall in the uplands, storm surges piling up ocean water on the coast, or a combination of these factors. Human activities that have exacerbated flooding effects include:

- construction of dikes and levees that reduces storage and displaces floodwaters;
- encroachment into the floodplain by development which displaces floodwaters;
- repeated forest fires that caused hydrophobic soil conditions in the uplands;
- construction of extensive networks of forest roads that changed subsurface flow and water storage;
- extensive logging decreased interception, infiltration and storage; and
- an increase in the landslide rate that put excessive sediment loads in the channels and the bay.

River flooding tends to occur in December and January during periods of heavy rain or a rain-on-snow event. Tidal and storm surge effects extend the flooding season to November to February. The floodplain acreage in the Kilchis subject to flooding is estimated at 660 acres, which is small compared to 4,900 acres for the Wilson River or 3,600 acres for the Trask River (TBNEP 1998).

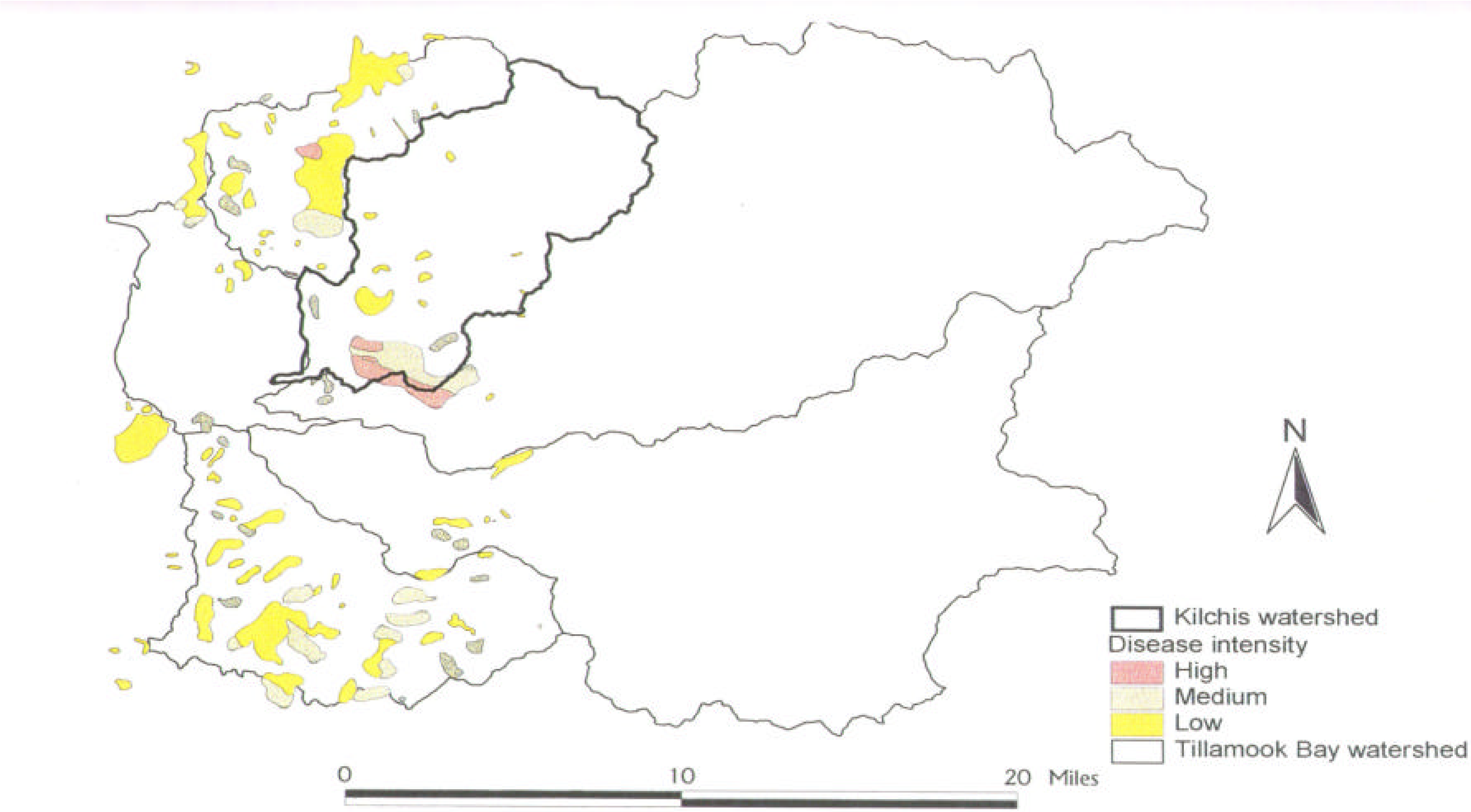


Figure 1-7. Extent of Swiss Needle Cast disease in the Tillamook Bay watershed in 1996. (Source: TBNEP GIS layer SNC96)

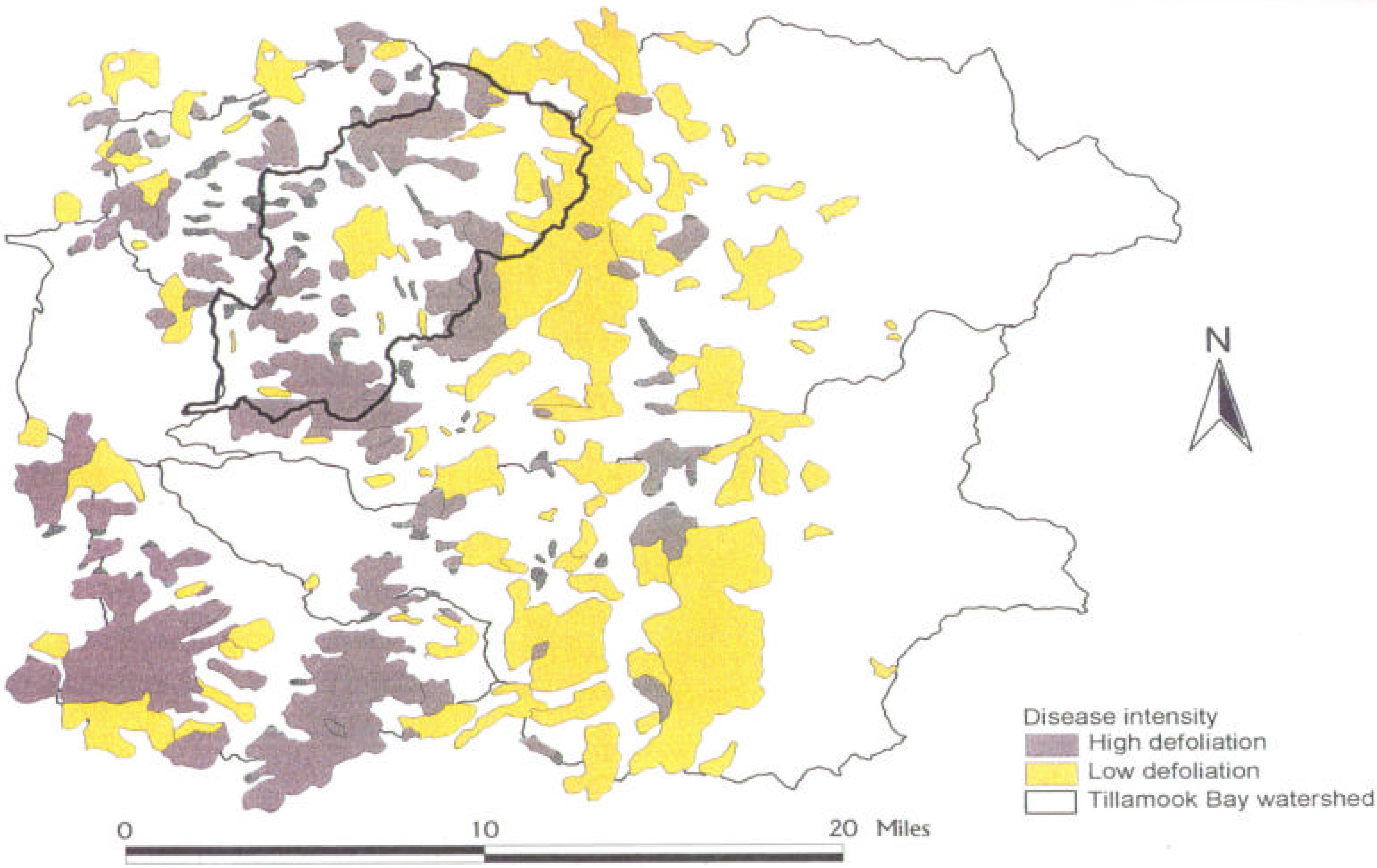


Figure 1-8. Extent of Swiss Needle Cast disease in the Tillamook Bay watershed in 1997. (Source: TBNEP GIS layers SNC97)

2.0 HYDROLOGIC CHARACTERIZATION

Introduction

The Kilchis River watershed is typical of the low-elevation, steeply-sloped Oregon Coastal basins. The basin has a drainage area of approximately 65 mi^2 with elevations reaching near 3,300 ft. Approximately 310,000 acre-ft (430 ft^3/s) of water discharge annually into Tillamook Bay from the Kilchis River, with approximately 87 percent of the annual discharge occurring from November to April. The watershed is underlain by Tertiary volcanic and sedimentary rocks of low permeability that store only a small volume of the annual precipitation. Consequently, streamflow is abundant in the wet season and is very low in late summer. The 7-day, 20-year low streamflow recurrence for the basin is estimated at 17 ft^3/s.

The topography of the Kilchis Basin is steep, causing flows to respond quickly from precipitation and providing potential for debris flows, which are caused by high levels of precipitation on steep, saturated, and unstable slopes. Peak flows are high in magnitude and respond within 24 hours of the peak precipitation. The 25-year recurrence peak flow is estimated at 18,200 ft^3/s. Mountains of the Oregon Coast Range are at a low elevation and do not collect snow that will supplement spring and summer flows. Instead, the snow that does briefly accumulate, is quickly washed away by winter rains. Only occasionally, as in the February 1996 flooding, does snow accumulate to significant amounts to influence peak flow magnitudes. Forest fires, timber harvesting, and roads associated with log transport have changed both the hydrologic response and sediment delivery of the natural watershed, to the detriment of the basin.

This section covers:

- climate,
- streamflows, and
- land and water interface.

Climate

Precipitation as shown in Figure 2-1 (from Daly and Taylor 1995) represents the distribution of measured rainfall as affected by orographic processes. It shows the variability that exists within the Kilchis Basin caused by the Coast Range barrier. The mean annual precipitation of the Kilchis Basin is approximately 136 inches (463,000 acre-ft). This total may be slightly low. There are two primary reasons for the under-measurement of rainfall: 1) almost all raingages undercatch high-intensity rainfall and rainfall driven by wind (by as much as 20 percent as reported by Larson and Peck 1974), and 2) raingages do not measure the precipitation contribution of fog (and dew) which is an important precipitation process in the Pacific Northwest and can yield as much as 35 inches annually (Harr 1982).

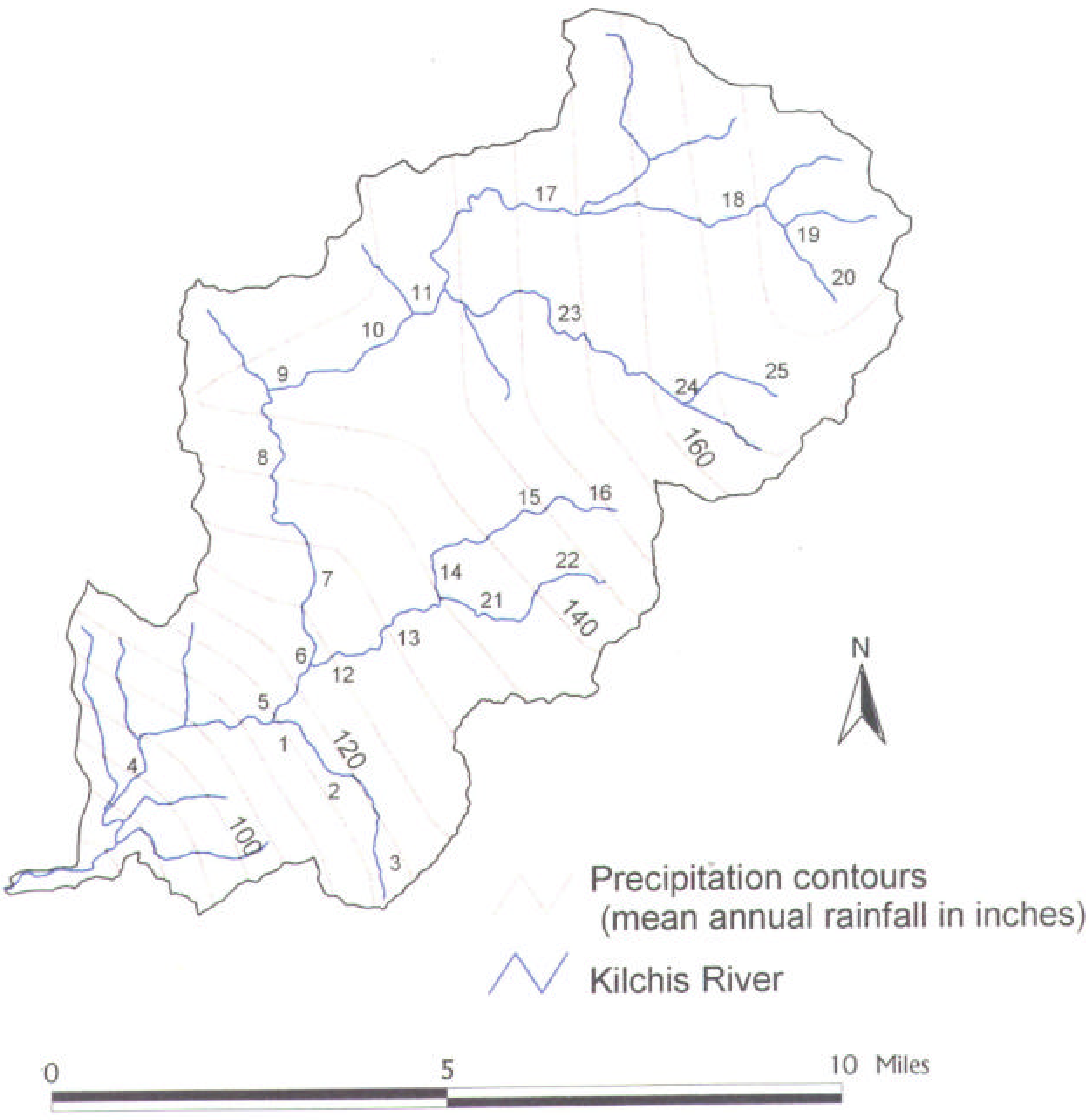


Figure 2-1. Average annual precipitation in the Kilchis watershed. (Source: TBNEP GIS layer PREC_CNT)

Precipitation has been recorded since 1889 in Tillamook with some periods of missing data. Table 2-1 is a listing of the monthly mean precipitation and snowfall showing the variability encountered during the year (Oregon Climate Service). The average annual precipitation in Tillamook for the 1961–90 period is 88.6 inches. The highest precipitation events occur from November through February. Table 2-2 is a listing of the five highest one-day to four-day events for the period 1961–97. A basin the size of the Kilchis River is expected to respond most to storms with one- to two-day duration times.

Table 2-1. Monthly means of precipitation and snowmelt at Tillamook, Oregon for 1961–90

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Precipitation	13.56	9.94	10.16	6.05	4.43	3.20	1.60	1.75	3.76	7.12	13.08	13.93	88.6
Snowfall	0.68	0.45	0.61	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.62	2.72

Source: Oregon Climate Service web page: www.ocs.orst.edu

Table 2-2. The five highest precipitation totals for 1-day to 4-day duration times at Tillamook, Oregon for 1961–90

1-DAY		2-DAY		3-DAY		4-DAY	
TOTAL	DATE	TOTAL	DATE	TOTAL	DATE	TOTAL	DATE
5.22	1/23/82	8.55	1/27/65	11.93	2/6/96	13.34	2/5/96
4.92	12/2/77	8.44	2/7/96	10.80	1/27/67	12.10	1/27/65
4.84	2/8/96	7.30	11/30/75	7.99	1/23/71	9.94	1/22/71
4.67	10/27/94	6.76	10/27/94	7.85	11/30/75	9.85	11/30/75
4.65	1/28/65	6.40	1/22/82	7.37	1/4/83	9.70	1/4/83

Source: Oregon Climate Service web page: www.ocs.orst.edu

The February 6–9, 1996 storm was the highest four-day event for the period of record for many locations in Oregon and Washington. In Astoria the event totaled 8.88 inches (0.64 inches higher than the old record), and at Newport the total was 9.81 inches, just 0.36 inches lower than the record (Taylor 1997). In Tillamook, the event totaled 13.34 inches, which was 1.24 inches higher than the old four-day record (1961–97) set on January 27–30, 1965 (Oregon Climate Service). The February 1996 storm produced the peak of record (greater than 200-year recurrence interval) for the Nehalem River near Foss and a peak with a 50-year recurrence interval on the Wilson River near Tillamook (Laenen 1997). One of the contributing factors to the peak magnitudes of the February 1996 floods was the snowmelt that occurred from snow that covered even low elevations of the Oregon Coast Range. The Natural Resources Conservation Service SNOWTEL site at Saddle Mountain recorded a snow-water equivalent loss of 14 inches (Taylor 1997).

Streamflows

Stream stage data were collected on the Kilchis River (14301450) by the Oregon Water Resources Department (OWRD) from October 1973 to November 1977, and November 1995 to present. The discharge computations provided by the OWRD are very high compared to what would be expected from a basin of this size, therefore, the data were not used for annual or peak flow computations because of the obvious error. However, the data are useful for low flow computations because the gage error is only occurring during higher flows.

Annual Flows

Mean annual flow for the Kilchis River can be roughly estimated using mean annual flows for the Wilson, Trask, and Nestucca Rivers. This is not as accurate as using flows calculated for Kilchis River and correlating them to flows at a nearby station, but it will have to suffice. The estimated mean annual flow of 430 ft^3/s translates into a total average annual discharge of 310,000 acre-ft of water. From nearby records, it is also estimated that about 87% of the discharge occurs on the average from November to April.

Peak Flows

Instantaneous peak flows for the Kilchis River can be roughly estimated using peak flows from the Wilson River to define a flood-frequency relation. The flood-frequency relation for the Wilson River given in Wellman *et al.* (1993) was updated to include annual peaks through 1997. Using a drainage area ratio, and an adjustment for higher rainfall, the 25-year recurrence peak on the Kilchis River is estimated to be 16,000 ft^3/s. The February 1996 flood peak on the Nehalem River, adjacent to the north, had a 200-year recurrence interval, and the Wilson River, adjacent to the south, had a 50-year recurrence interval. Because the Kilchis Basin is smaller than either the Nehalem or the Wilson Basins, the basin would respond to a maximum one- to two-day precipitation instead of a four-day maximum, and therefore have a lower recurrence interval. A good guess for the February 1996 flood peak on the Kilchis River would be about a 10-year recurrence interval.

To understand flood peak recurrence interval the following explanation is given (Laenen 1997): A flood magnitude given a 100-year recurrence interval does not mean that a flood of this magnitude will occur only once in 100 years. Statistically speaking, it means that the flood magnitude has a 1% chance of being equaled or exceeded in any given year. Practically speaking, it means that over the life of a 30-year mortgage, the odds of property within the 100-year floodplain boundary being flooded are greater than 26 %, or at least 1 in 3.

Low Flow

Low flows are a good indicator of groundwater potential in the basin because streamflow at this time is comprised primarily of water from the regional groundwater aquifer. A 7-day low flow, normalized by dividing the flow value by basin drainage, can be compared between basins. Low flows in the Kilchis and Wilson Rivers were correlated to define a relation used to compute the 7-day, 20-year recurrence low flow ($Q_{7,20}$)for the Kilchis River. With a correlation r^2 greater than 92%, the $Q_{7,20}$ computed to be 17 ft^3/s, and results in an estimated yield ($Y_{7,20}$) of 0.27 $ft^3/s/mi^2$. The estimated $Y_{7,20}$ for the Kilchis River can be compared to the $Y_{7,20}$ for streams that are not heavily regulated such as the Nestucca River (0.25 $ft^3/s/mi^2$) and the Trask River (0.34 $ft^3/s/mi^2$) which have yields of the same magnitude, and to rivers with significant aquifer systems such as the Clackamas River (0.94 $ft^3/s/mi^2$) which has a significantly higher $Y_{7,20}$.

Land and Water Interface

Subsurface Flow

For timbered basins in Western Oregon, except for flow in stream channels, very little flow runs over the land surface, even during high intensity rainfall events (Risley 1994). Forest litter and soils that contain dense tree root systems provide water pathways beneath the surface. For peak flow events, almost all non-channelized flow is subsurface flow. Roads that cross hillslopes intercept the subsurface flow and direct it to drainage ditches that convey some of their water flows to the stream channel system. A significant network of roads may increase the peak flow response and the peak magnitude (Nakama and Risley 1993).

Landslides/Debris Flows

Landslides are the product of steep slopes, high intensity rains, and the physical concentration of water beneath the land surface creating a slip surface. Slip surfaces can occur naturally because of the topography and soil-rock interfaces, but they can also occur when slopes are increased to accommodate roads (Mills 1997) and road drainage concentrates subsurface flows (Burns 1997). Debris flows can skew the flood-frequency distribution at a location where the analysis consists primarily of peaks flows caused by precipitation. Debris flow-affected peaks should be considered a different statistical population.

3.0 STREAM CHANNEL

Introduction

The stream and river channels conduct the water and sediment from the headwaters to the estuary, provide habitat for numerous species of fish, wildlife and plants, and exhibit the effects of changes in hydrology due to human activities. The habitat values in the channel are a result of the interactions between environmental factors (streamflow, sediment, large woody debris, climate and geology) modified by the effects of human activities. The following discussions evaluate various habitat factors and human activities affecting the stream channels. This section covers:

- general characteristics of stream channels,
- channel complexity due to large woody debris content,
- channel complexity due to boulder content,
- debris flows and stream channel scouring,
- stream channel bank erosion,
- gravel removal,
- stream channel widening, and
- instream enhancement sites.

General Characteristics of Stream Channels

The Kilchis system is a relatively high gradient system with only a fairly short section of the mainstem in the lowlands that is very low gradient. All tributary streams have confined channels due to narrow canyons for nearly all of their lengths. The channel habitat types (CHT) for all streams in the watershed were determined using the protocol contained in the Governors Watershed Enhancement Board (GWEB) Watershed Assessment Manual (GWEB 1997). Hathaway, Stasek, Neilson and Squeedunk Sloughs were not included because the results of their stream surveys were not yet available. A summary of the CHTs by subwatershed is presented in Table 3-1 and the CHTs for all streams are presented in Appendix A. Figure 3-1 shows the subwatersheds for the Kilchis watershed as determined by Randy Stinson of the Tillamook Soil and Water Conservation District. The subwatersheds were delineated for use in the TR20 hydrologic model, which was subsequently run for the Kilchis. The model output was not valid due to the model not being designed for this type of watershed; the model results are not presented in this report.

Table 3-1. Channel habitat types for the subwatersheds of the Kilchis River watershed

		Channel		Habitat		Types			Total
Subwatershed	FP2	FP3	LC	MM	MC	MV	SV	VH	Length
1	0	0	0	0	0	8300	7700	12900	28900
2	0	0	0	0	15200	3000	5200	32900	56300
3	0	0	0	0	6500	0	14800	41800	63100
4	0	0	0	0	17500	0	3800	25800	47100
5	0	0	0	0	0	7000	15100	17700	39800
6	0	0	0	0	21000	0	7900	26400	55300
7	0	0	0	6200	8000	0	18900	49200	82300
8	0	0	0	12000	0	0	10200	17300	39500
9	0	0	9800	0	0	0	3500	16000	29300
10	0	0	0	0	3200	8000	13300	17600	42100
11	0	0	0	0	0	10200	7500	23000	40700
12	0	0	5500	0	5000	1000	6800	11700	30000
13	0	800	5000	0	0	0	0	2500	8300
14	0	2000	0	0	0	6000	12900	37100	58000
15	0	2200	10000	0	0	2500	3000	11400	29100
16	0	0	0	0	0	3000	1200	3800	8000
18	0	2800	0	0	0	4000	3000	2800	12600
19	0	2500	0	0	0	2000	2200	2500	9200
20	0	2000	0	0	0	2800	3000	3200	11000
17, 21–24	21000	0	0	0	0	0	0	0	21000

Note: CHTs: FP2 floodplain large/medium; FP3 floodplain small stream; LC low gradient constrained; MM moderate terrace/hillslope confined; MC moderate gradient constrained; MV moderately steep, narrow valley; SV steep headwater; VH very steep headwater. Numbers in the cells represent the total length in feet of stream channels for that CHT in the subwatershed.

Source: GWEB (Governors Watershed Enhancement Board). 1997. Oregon Watershed Assessment Manual. Non Point Source Solutions. 213 pp.

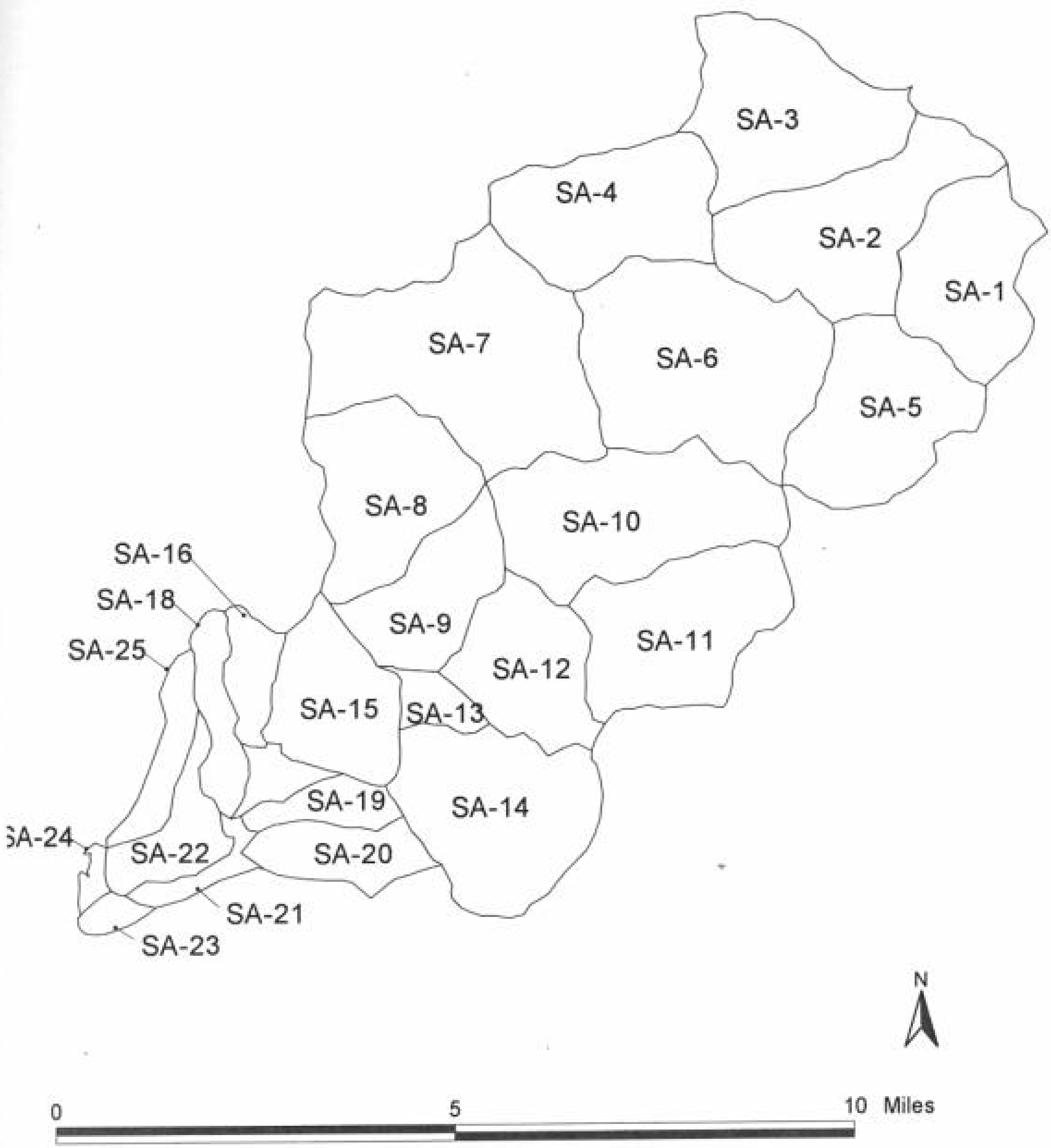


Figure 3-1. Sub-watershed of the Kilchis watershed. (Source: SWCD AutoCAD Drawing)

Channel Complexity Due To Large Woody Debris Content

The stream channel content of large woody debris (LWD) was quantitatively evaluated for the 25 stream reaches in the Oregon Department of fish and Wildlife (ODFW) stream habitat surveys (ODFW 1995a). The data collected for the surveys includes: the number of pieces, their size and volume, and the number of key wood pieces (defined as greater than 15 cm diameter and longer than the active channel width). The surveyed reaches were rated for current LWD using ODFW habitat quality benchmarks for three parameters: the number of LWD pieces per 100m, the volume of LWD per 100m, and the key pieces of LWD. The ratings for the three parameters were summed for a possible combined score range of zero to six points. Table 3-2 lists the benchmark values for these and other parameters related to habitat values. Figure 3-2 presents the LWD rating by reach for the three parameters listed above and LWD recruitment potential.

Kilchis Mainstem

The mainstem has poor ratings for all three measures (See Table 3-3); all eight reaches have summary ratings of zero points each (Reaches 4–11). The mainstem channel ranges from 25 to 42m active channel width, so key pieces are particularly important for retaining smaller pieces of LWD. Additionally, there has been ongoing clearing of LWD from the channel in the lower, agricultural reaches of the mainstem.

Clear Creek

The three reaches vary from a low of zero points for the lowest reach (Reach 1) to two for the middle reach and five for the highest reach (Reach 3); there is a lack of key pieces throughout the three reaches.

Little South Fork

This fork has poor summary ratings of zero for the lower three reaches (Reaches 12–14). Although poor, these LWD levels are not as low as the mainstem reaches. The Little South Fork has combined ratings of seven and nine for the two highest reaches (Reaches 15 and 16); only the second to highest reach has quite good ratings for the number and volume of LWD and key pieces.

Sam Downs Creek

Sam Downs has intermediate ratings of two and four for its two reaches (Reaches 21 and 22); the LWD ratings are weakest for key pieces of wood.

Table 3-2. Stream channel habitat benchmarks

PARAMETER	SUBFACTOR	UNITS	GOOD	FAIR	POOR
Pool Area		% of channel area	=>35	10<x<35	<10
Pool Frequency		# of channel widths	<=8	8<x<20	=>20
Residual Pool Depth	gradient <3% or <7m wide	meters	=>0.5	0.2<x<0.5	<=0.2
	gradient >3% or >7m wide	meters	<=1.0	0.5<x<1.0	<=0.5
Riffle width/depth ratio	gradient <3%	ratio	<=10	10<x<30	>=30
Silt/sand/organic matter		% or area	<=10	10<x<25	>=25
Gravel available		% of area	>=35	15<x<35	<=15
Shade	ACW <12m wide	% for reach	>=70	50<x<70	<=50
	ACW >12m wide	% for reach	>=60	40<x<60	<=40
LWD Pieces		# pieces/100m	>=20	10<x<20	<=10
LWD volume		cubic m/100m	>=30	20<x<30	<=20
LWD Key (>50cm dia. and >ACW long)		# pieces/100m	>=3	1<x<3	<=1
LWD Recruit. Potential*	1) age/size	cm diameter	old (>90 cm)	medium (>50 cm)	young (maj. small)
(Uses 3 subfactors)	2) density	% crown closure	dense (>67%)		sparse (67%)
	3) species	species	conifer (>70%)	mixed	deciduous (70%)

Note: * Washington Forest Practices Board. 1993. Standard Methodology for Conducting Watershed Analysis. Version 2.0.

Source: (except LWD Recruit. Potential): ODFW (Oregon Dept. of Fish and Wildlife). 1995a. Aquatic Inventories Project Physical Habitat Surveys: Kilchis and Tillamook River Basins.

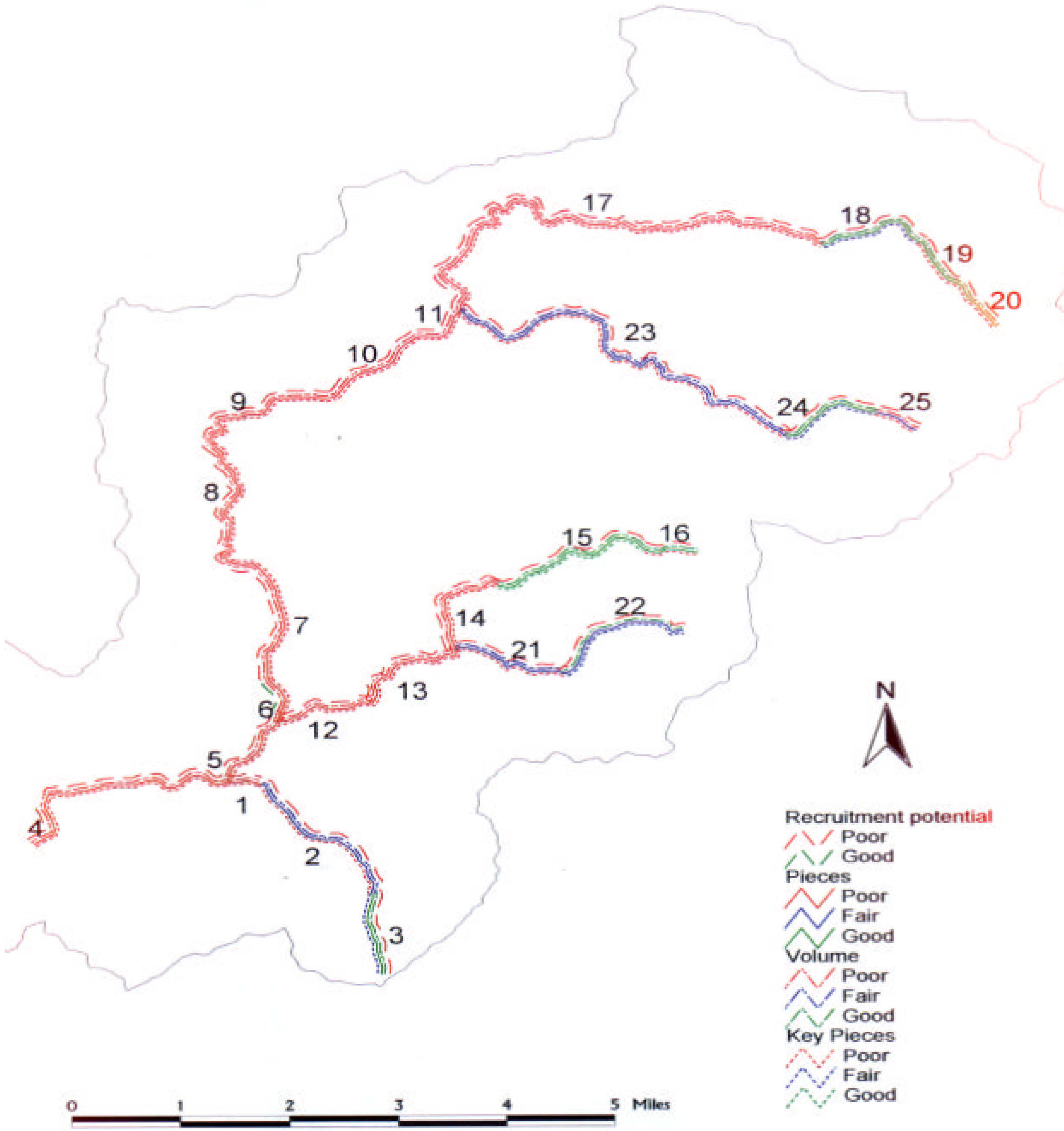


Figure 3-2. LWD characteristics for the surveyed reaches of the Kilchis River. (Source: TBNEP GIS layer KILRCH)

Table 3-3. Riparian scores for shade, pieces of LWD, volume of LWD, key pieces of LWD, recruitment potential of LWD, and summary riparian score

Reach	Stream Name	Shade Score*	Pieces Score	Vol Score	Key Score	Recr LWD Score**	SUM Rip Score
1	CLEAR CREEK	2	0	0	0	0	2
2	CLEAR CREEK	1.8	1	1	0	0	3.8
3	CLEAR CREEK	2	2	2	1	0.2	7.2
4	MAINSTEM	1	0	0	0	0	1
5	MAINSTEM	0.6	0	0	0	0	0.6
6	MAINSTEM	2	0	0	0	2	4
7	MAINSTEM	2	0	0	0	0.7	2.7
8	MAINSTEM	2	0	0	0	0	2
9	MAINSTEM	2	0	0	0	0	2
10	MAINSTEM	2	0	0	0	0	2
11	MAINSTEM	2	0	0	0	0	2
12	L. S. F. KILCHIS	0	0	0	0	0	0
13	L. S. F. KILCHIS	0.5	0	0	0	0	0.5
14	L. S. F. KILCHIS	0.7	0	0	0	0	0.7
15	L. S. F. KILCHIS	1	2	2	2	0	7
16	L. S. F. KILCHIS	2	2	2	0	0	6
17	N. F. KILCHIS	0.4	0	0	0	0	0.4
18	N. F. KILCHIS	2	2	2	1	0	7
19	N. F. KILCHIS	2	2	2	0	0	6
20	N. F. KILCHIS	2	2	2	0	0	6
21	SAM DOWNS	0	1	1	0	0	2
22	SAM DOWNS	0	1	2	1	0	4
23	S. F. KILCHIS	2	1	1	0	0	4
24	S. F. KILCHIS	2	2	2	1	0	7
25	S. F. KILCHIS	2	1	0	0	0	3

Note: Score range is: 0 poor, 1 fair, and 2 good. Summary score range is 0–10, with 0–3 poor, 4–6 fair, and 7–10 good.

*The "open sky" measurement in the Kilhab database was used to determine the amount of shading; if there is no shading the reading is 100 and if there is total shading the reading is 0. This measurement has the following drawbacks: the orientation of the stream is not taken into account (a north-south orientation would allow more sunlight to reach the stream than an east-west orientation would with the same amount of vegetation); the measurement involves observer bias and therefore is not that repeatable (Robison, G. personal communication 1998). See Table 3-2 for the shade benchmark values.

** The ODFW stream habitat surveys (Geographical Information System [GIS] layer Kilhab) gives information regarding the riparian vegetation within sample plots spread throughout the watershed (84 sample plots). The 30m by 5m plots were laid out perpendicular to the channel on both sides and spaced every 30 habitat units. The information was divided into left bank and right bank riparian vegetation.

North Fork

This fork has combined ratings ranging from zero for the lowest reach (Reach 17) to five, four and four for the upper three reaches (Reaches 18–20). Again the most glaring weakness is the lack of key pieces of wood, while the number and volume of LWD pieces is adequate to good.

South Fork

The South Fork has combined ratings of two, five and one going from the lowest to highest reaches respectively (Reaches 23–25). The weakest scores are for key pieces of wood and only the middle reach has quite good numbers and volume of LWD pieces.

No data has been collected for the other 92 perennial tributaries, but Stinson (Stinson, R. personal communication 1997) stated that some tributaries, particularly those without road access (which allows for salvaging of logs) have adequate levels of LWD in the stream channels. This would agree with the trend of better ratings in the higher reaches with narrower channels for Clear Creek, the Little South Fork, the North Fork, and Sam Downs Creek. In the tributary streams, alder logs have a greater chance of forming jams and storing sediment due to the smaller width and power of these streams. The abundant supply of alder logs and the presence in some streams of large, old key pieces of wood could give these streams better instream structure than wider channels in the watershed.

Large-scale salvage logging ended in the late 1960's in the TSF so that any logs left at that time would only be removed by natural forces such as flooding or decomposition. The exception is cedar logs, which were still being individually salvage logged as late as 1997 (LaFrance, D. personal communication 1998). Very few standing dead trees were left at the close of salvage logging because they were felt to be a fire hazard. Many logs were left on the ground because they were unmerchantable; the majority of them were species that lose their value faster when dead and down such as hemlock and spruce. These logs left lying on the forest floor and in stream channels constitute the majority of non-alder LWD inputs to stream channels in the Kilchis Watershed since the end of salvage logging operations. At times they have been flushed out of tributary channels into larger channels by floods and formed debris jams. This process appears to have largely tapered off now that 47 years have passed since the last burn.

The overall message for the current status of LWD in the surveyed reaches of the Kilchis is that only one reach has adequate key pieces of wood to create jams for storing sediment and providing fish habitat. Those reaches and tributary streams with road access are much more likely to have had large logs salvaged out of the channels or were cleared of large logs to prevent jams during the period when this practice was thought to be necessary. Most surveyed reaches are deficient in the number of LWD pieces and total wood volume, particularly in the main stem and the lower end of the three forks, where there is very little wood at all. The vast majority of the current LWD supply in the Kilchis watershed consists of alder logs, which have relatively small diameters and decay fairly rapidly. Although alder logs may provide valuable pieces of LWD for the smaller tributary streams, their utility in the wider channels of the mainstem and the lower ends of the three forks is limited.

Channel Complexity Due To Boulder Content

The stream channel content of boulders was quantitatively evaluated for the 25 stream reaches covered by the ODFW stream habitat surveys (ODFW 1995). The data collected for the surveys consists of the number of boulders larger than one-half meter in diameter per 100m of stream channel. The range of values found in the stream surveys was 1.0–62.5 boulders per 100m of stream channel.

Kilchis Mainstem

The mainstem has relatively low numbers of boulders (range 3.6–12.9/100m) in the lower three reaches (Reaches 4–6), which is expected for the low gradient, broad reaches of the river. The middle three reaches (Reaches 7–9) have good numbers of boulders (range 20.8–27.0/100m) for this gradient. This may be due to steep gradient tributaries that can deliver boulders to the mainstem. The upper two reaches (Reaches 10 and 11) have lower numbers of boulders (13.8 and 18.0/100m) than needed to provide channel complexity. The current and future potential LWD in these two reaches is rated poor for all four characters and either LWD or boulder addition would help replace the complexity that is lacking.

Clear Creek

Clear Creek has very low boulder counts for the lower and upper reaches (Reaches 1 and 3), but quite a good count in the middle reach (1.5, 38.2, and 1.0/100m respectively). Although the upper reach has good LWD scores, the lower reach has all poor LWD scores and could use more boulders to help replace the lack of complexity from LWD.

Little South Fork

This fork has quite good boulder counts (39.7–55.6/100m) for the four upper reaches (Reaches 13–16), but only 7.6/100m for the lowest reach (Reach 12). The lowest reach has all poor LWD ratings and could use the complexity provided by boulders, but the channel is 30m wide and the gradient is low so it is unlikely that there will be natural movement of boulders into the reach.

Sam Downs Creek

Sam Downs has high numbers of boulders (82.0 and 62.5/100m), which helps make up for the lack of complexity provided by the generally low LWD levels in these two reaches (Reaches 21 and 22).

North Fork and South Fork

These forks have moderate to high boulder counts (range 24.4–60.5/100m) in the seven reaches. When the boulder counts are combined with the current LWD, the channels should have sufficient complexity, which is born out by complexity rating scores being in the mid- to upper-ranges (range 1.4–3.0) relative to the scores for the rest of the river system (see Table 3-3, Complexity Score). The exception is the lowest reach of the North Fork (Reach 17), which has all poor LWD scores and a moderately good boulder count for a low complexity rating of 1.4.

Boulder Enhancement Projects

The reaches which could be considered for boulder placement projects, if any were to be considered, are the upper two reaches of the mainstem (Reaches 10 and 11), the lowest reach of Clear Creek (Reach 1), the lowest reach of the Little South Fork (Reach 12), and possibly the lowest reach of the North Fork (Reach 17). Clear Creek and the Little South Fork have the highest priority assigned in the ODFW site selection process (Thom and Moore 1997). Equipment access is of critical importance for this type of instream enhancement and must be considered during the project planning phase.

Debris Flows and Stream Channel Scouring

While some streams in the Tillamook Bay watershed have been affected by splash dams, as outlined in the Forest Service Report (Sedell and Duval 1985), Sedell and Duval failed to document any splash damming in the Kilchis watershed. Therefore, scouring that has occurred in the Kilchis watershed is probably a result of natural and human caused landslides and debris flows.

Channelized debris flows affect stream systems in several ways. At the origin of the landslide, a mass of soil, rock, and vegetation breaks away leaving behind only bedrock or parent material. Once the material reaches the stream, it liquefies and becomes a channelized debris flow. As this mass moves downstream it generally makes the stream less complex through: removing vegetation in and near the stream, scouring the stream course of sediment, filling pools, sweeping away large woody debris, and burying or sweeping away bedload sediment in riffles. As the channelized debris flow nears the end of its course and slows, a tributary junction where the junction angle is high may stop the flow. Usually there is a debris plug left at the point where the flow comes to rest. This can result in a complete clogging of the stream with gravel and debris several meters deep, effectively changing the stream morphology.

As the stream reacts to this change, a new channel may be cut to one side of the debris mass through the riparian zone. As the bank is undercut, it collapses into the stream, allowing the channel to cut further into the riparian zone thus further widening the channel. This chain reaction can result in the destruction of a large amount of riparian habitat both along the flow path and downstream of its termination point. This effect is enhanced if the riparian stands are not very resistant to erosion, as many of the riparian zones are in our study area (see first section of Riparian chapter for discussion).

At least two, and possibly several more, landslides triggered by the February 1996 storm generated debris flows in the Kilchis Watershed. A flow covering nearly a mile and a half of French Creek was initiated below Firebreak 3W Road and ended at the confluence with Schroeder Creek (Schroeder Creek enters the North Fork in Reach 17). A second large flow occurred on a tributary of the North Fork of the Kilchis that extended for approximately one-half mile and ended at the confluence with the tributary from Kilchis Falls (enters the North Fork in Reach 18). The initiating landslides for both of these flows originated in topographic depressions just below forest roads.

A study by the ODF (Mills 1996) indicates that road-related landslides are the highest contributor of material to streams. Of the 57 road-related landslides recorded in the study area on the Wilson River caused by the February 1996 extreme storm, 94% were associated with a failure of fill materials along a forest road. It is possible that human-caused landslides are increasing the occurrence of channelized debris flows in the Kilchis watershed.

Stream Channel Bank Erosion

The concern with bank erosion is not whether it is occurring, but how much and where. Channel migration, which causes bank erosion on the outside of meander bends, is normal and to be expected. Poor bank conditions, such as the lack of riparian vegetation, can accelerate erosion and become a concern.

The stream habitat surveys performed by ODFW on the forested and upper agricultural portions of the Kilchis watershed included observations on bank erosion. For each habitat unit the presence or absence of active erosion on both banks was noted; Figure 3-3 is a GIS map of the active erosion by habitat units. The habitat unit values were summed for each reach to get total bank erosion and these reach totals are discussed below. The information recorded in the habitat surveys does not indicate the type of bank erosion and thus does not allow an analysis of whether it is normal of accelerated erosion.

Kilchis Mainstem

The lowest two reaches (Reaches 4 and 5) lie entirely in the agricultural portion of the watershed and had 29% and 11% of the banks actively eroding. These reaches had very poor riparian scores, which indicates the loss of riparian bank stabilization due to tree removal. When the loss of riparian stabilization is combined with cattle access to the stream channel and instream gravel mining, then the result can be loss of bank stability. The next six forested reaches upstream had very low levels of active erosion ranging from 0 to 6% with a mean of 1.5%.

Little South Fork

The lowest reach (Reach 12) had 8% actively eroding banks. This may be due to the poor riparian ratings in the lower reaches of this fork. However, the next two reaches upstream had very low bank erosion of 0 and 1%, respectively. The two highest reaches had active erosion of 11% and 25%, which may be an indication of debris flows entering the main channel from tributaries in the upper reach.

North Fork

The lower two reaches (Reaches 17 and 18) had active erosion of 11% and 15% respectively. The upper two reaches had values of 58% and 53% when the survey was conducted in February–April 1995. Since that time, the February 1996 storm caused at least one debris flow on a tributary to the North Fork (approximately ½ mile long), which stopped at the confluence forming the upper end of Reach 20. This debris flow has severely impacted habitat values in the North Fork tributary through channel destabilization, bed agradation, the loss of riparian trees, and small landslides. The resulting material continues the process of bed agradation and erosion downstream into the salmon core area.

South Fork

Active erosion ranged from 22–40% for the lower reach (Reach 23) and 16% for the upper reach. High percentages of actively eroding banks are usually indicative of relatively recent debris flows (Stinson, R. personal communication 1997), so the 40% active erosion may indicate the presence of one or more debris flows on tributaries to the upper reach of the South Fork. No field survey for debris flows was conducted on the South Fork.

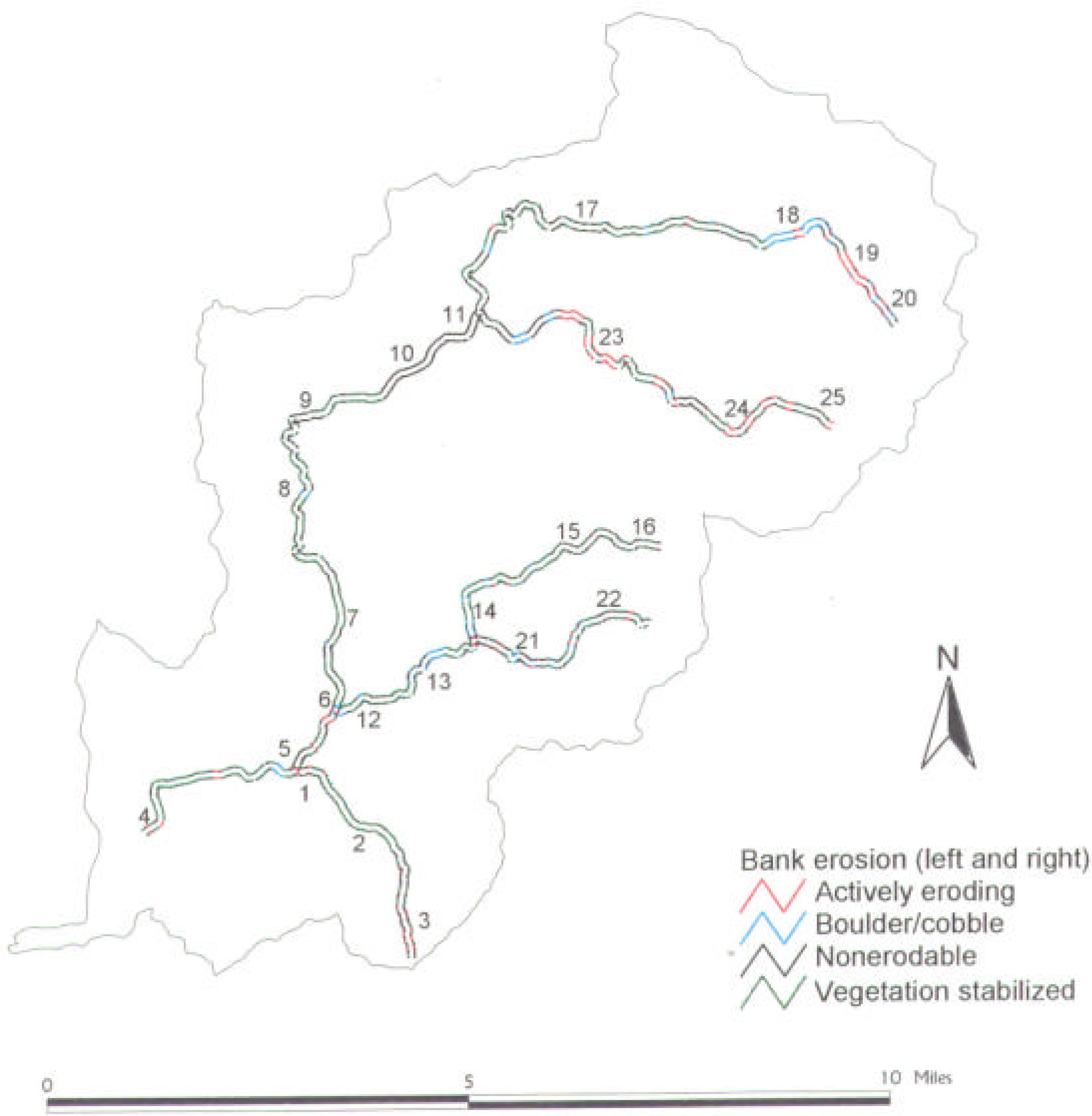


Figure 3-3. Bank erosion for the surveyed reaches of the Kilchis River. (Source: TBNEP GIS layer KILHAB)

Sam Downs Creek

The lower and upper reaches (Reaches 21 and 22) had active erosion of 16% and 20% respectively. Fair to good riparian ratings in these reaches indicated that the banks probably had adequate tree cover. A road washout producing approximately 2400 yd^3 on Sam Downs Road in February 1996 contributed a large quantity of material to the channel in Reach 22. This has caused bed agradation and additional bank erosion above the 20% found in the 1995 stream habitat survey, although the increase has not been quantified.

Clear Creek

The three reaches (Reaches 1, 2, and 3) have active erosion of 32%, 16% and 35% respectively. A number of debris flows have entered the stream channel in the upper reaches due to clearcutting of steep slopes in recent years. This destabilized the upper reach where they entered and to some extent continued into the middle reach as well. Some of the material would have deposited in the lower reach, which has a gradient of only 2%, probably developing a bedload plug.

Debris flows entering stream channels have caused bank erosion, stream channel widening and loss of channel complexity in a number of areas around the forested portion of the Kilchis watershed. It is difficult to determine if the current level of debris flows and resulting bank erosion are above normal background levels for this watershed because there is no baseline study to compare current levels against. These areas would normally be used by salmon for spawning and rearing habitat, but the impacts associated with debris flows drastically reduce habitat values in the affected reaches and preclude effective utilization of the habitat by salmon. Eventually the bedload material could form high quality spawning beds, but the lack of instream LWD reduces the potential habitat quality.

Gravel Removal

The location of gravel mining sites in the Tillamook Basin is shown in Figure 1-6. The harvesting of gravel has a wide range of effects on the stream channel and fish habitat values. Similarly, not harvesting gravel has a wide range of effects on the same parameters. The following paragraphs are a general discussion of the effects of gravel harvest on the stream channel and fish habitat values with specific references to the lower portion of the Kilchis River.

Various impacts of gravel harvesting on the flow hydraulics, channel morphology, and sediment transport have been documented in the report titled *Gravel Disturbance Impacts on Salmon Habitat and Stream Health* (Oregon Water Resources Research Institute [OWRRI] 1995). These impacts include:

- bed degradation at the harvest site, which can expose and undermine structure supports (*i.e.*, bridge supports);
- steepening of the local river gradient, which can cause head-cutting, bed degradation and bank undercutting upstream of the site;
- interception of sediment, which can cause bed degradation downstream from the site;
- depletion of gravel depth and exposure of other substrate materials; bank destabilization, destruction of riparian vegetation, and potential for aggravated bank erosion;
- increased channel meandering due to greater bank erosion; and
- adverse effects on groundwater levels and vegetation in riparian zones due to lowered bed elevation.

The localized, downstream and cumulative impacts of gravel harvesting on salmon are also presented in the OWRRI (1995) report. The impacts include:

- simplification of the complex morphology of the channel reducing the diversity of habitats;
- net lowering of the general bed elevation with possible decoupling of the channel from its riparian zone and floodplain;
- destabilization of the channel banks including removal or undercutting;
- reduction of energy dissipation possibly resulting in local destabilization;
- increased suspended sediment availability, transport, water turbidity, and gravel siltation;
- decreased light penetration with resulting impacts on benthic organisms and energy relations;
- removal of spawning gravel reducing the amount of usable spawning habitat;
- direct damage to spawning areas;
- changed substrate composition with impacts on habitat and bed stability;
- greater foot and vehicle access to spawning sites resulting in disturbance of redds and destruction of eggs or developing embryos;
- downstream erosion due to interruption of the gravel supply;
- increased suspended material reaching downstream habitats from disturbance sites;
- downstream embedded stream gravel in or under a fine layer of silt;
- downstream covering of the non-gravel bed with sand, silt, or mud in slow-moving parts of the river;
- downstream alteration of the aquatic community;
- blockage of access for adult salmon migrants due to physical or thermal changes;

- upstream alterations such as head cutting, erosion, increased velocities, and concentrated flows,
- decreased primary productivity due to decreases in diatoms and other benthic algae;
- increased densities of rooted aquatic plants that may be unusable to most aquatic invertebrates;
- changed invertebrate assemblages due to changes in species composition;
- reduction in drifting organisms that are the primary food source for salmon;
- slow biotic recolonization onto substrates;
- reduced food availability to fish;
- loss of well-aerated gravel leading to increased fish egg and fry mortality, and
- decreased fish biomass and fish species diversity due to less food and impacts to spawning grounds.

All of these impacts are further exacerbated by multiple extraction sites and other land-use and natural disturbances. The impacts of gravel extraction are not always closely connected in time with the harvesting because it may take a large discharge event to bring about many of the physical changes that impact habitat values (OWRRI 1995). These impacts are the most disruptive when the gravel harvest is occurring in-channel, including bar-scalping as done on the Kilchis.

Possible positive effects of instream gravel extraction (Stinson, R. personal communication 1996) on flow hydraulics, channel morphology, and sediment transport include: 1) gravel harvest lowers the riverbed increasing channel capacity and reducing overbank flows in developed floodplains; and 2) harvest can remove gravel plugs (excessive accumulations) that are causing bank erosion as the river widens to maintain its channel capacity. These effects may be particularly important in the Kilchis watershed because: there is a large bedload in some forested portions of the watershed due to debris flows, the banks of the lower main channel lack adequate riparian stands to protect them from erosion, and the floodplain contains a number of dairy operations and homes that are susceptible to damage from overbank flows.

Possible positive effects of instream gravel extraction on salmon are also presented in the OWRRI (1995) report. The positive effects include: 1) the harvest increases the river cross-section reducing flow velocities and this may reduce stresses on an eroding bank; 2) the deepened zone of the channel may be used to redirect flow for a purpose beneficial to salmon; and 3) the deepening may improve fish passage in an area where water depth would otherwise be inadequate. These effects do not appear to be valuable in the Kilchis because fish passage due to inadequate depth is not a problem, and there are no known sites where the flow needs to be redirected to aid salmon.   As stated above, the riparian stands are not adequate to protect the banks in the lower Kilchis, but the eroding banks can be addressed using other measures that don’t have as many impacts on salmon as gravel harvest does.

Stream Channel Widening

Three streams impacted by debris flows resulting from the February 1996 storm were analyzed for stream impact using the RAPID technique (Grant 1988). The impact width of a debris flow is much wider than the active channel on small streams. The debris flows on these streams impacted the riparian areas reducing shading and removing potential LWD, destabilizing the channel and aggrading the bed. Measurements were also made on three sets of aerial photos of the active channel width (ACW) of the mainstem Kilchis (between River Miles 1 and 4) over time.[3]

The streams selected for impact analysis were: French Creek from its confluence with Schroeder Creek (enters Reach 17) to its headwaters; Slide Creek from its confluence with the Kilchis mainstem (enters Reach 17) to its headwaters; and a tributary to the North Fork of the Kilchis (Reach 18) from its junction with the North Fork to its headwaters. Measurements of canopy openings (as a surrogate for impact width) were made from the initiation point (landslide that caused the debris flow) along the path of the debris flow to the point where it stopped, which in these three cases was at or near a confluence. The following paragraphs present discussions of the individual streams followed by a discussion of the lower Kilchis main channel.

French Creek had a debris flow in February 1996 that resulted from two shallow, rapid landslides originating in the fillslope below Firebreak 3W Road. The landslides originated on separate small channels, which joined after approximately 950 feet. From that confluence, the channelized debris flow proceeded downstream another 6,090 feet before stopping near the confluence with Schroeder Creek (see discussion under debris flow question). The average canopy opening for French Creek in the 1960 photos was 43.2 feet and in the 1996 photos was 67.6 feet, for a 56% increase in width.

[3] Three photo sets were used for the stream channel widening analysis. They are: Farm Service Agency 1953; ODF 1960; and ODF 1996.

Slide Creek had a debris flow resulting from shallow, rapid landslides that originated just below a ridgeline harvest road and a clearcut. The landslides traveled down small, steep tributaries and joined in the main Slide Creek channel, which resulted in 3770 feet of the main channel being affected. The average canopy opening for Slide Creek in the 1960 photos was 21.0 feet and in the 1996 photos was 58.8 feet, for a 180% increase in width.

A tributary to the North Fork had one debris flow resulting from a shallow, rapid landslide, which originated approximately 125 feet below a forest road. The road may have concentrated water infiltration to a subsurface impervious plane, where it collected and resulted in a landslide. From the initiation point, the debris flow traveled 3,700 feet along the channel and ended at a confluence with the North Fork. The average canopy opening for the North Fork tributary in the 1960 photos was 24.6 feet and in the 1996 photos was 45.4 feet, for an 84% increase in width.

All three of these streams have undergone debris flow events that drastically impacted their channel habitat and riparian stands. They currently have heavy bedloads of unsorted material causing bed agradation and very extensive bank erosion. The heavily impacted riparian zones are continuing to collapse into the channel due to undercutting from ongoing bank erosion. The 1960 photo set was also taken during a period of channel widening and bank instability following the Tillamook Burn and during the salvage logging. It is probable that the channels were narrower before the Tillamook Burn and salvage logging, but no photo set was located that predated these perturbations. Currently, the channel widening appears to be confined to those channels that have recently undergone a debris flow and resulting streambed agradation. The riparian canopy precludes measurement on aerial photos of other streams to determine if they have widened or not during this period.

The ACW of the lower main Kilchis channel was measured at eight points between River Miles 1 and 4 using the Farm Service Agency 1953, the ODF 1960 and the ODF 1996 photo sets. The average ACW in 1953 was 184.3 feet, in 1960 it was 134.8 feet and in 1996 it was 122.2 feet, for a decrease in width of approximately 27% between 1953 and 1960, and an additional decrease of approximately 10% between 1960 and 1996. During the 43 year period covered by the three photo sets the river stabilized and at least partially recovered from the effects of the Tillamook Burn and the salvage logging that followed. Other factors were also involved in the stabilization such as increased use of riprap and bank plantings to secure eroding bank sections.

The primary problem producing channel widening in the upper portions of the Kilchis watershed is the incidence of debris flows resulting from shallow, rapid landslides. These landslides that were examined on the ground originated below forest roads. The after-effects of the torrents are impacted channels, severe degradation of fish habitat values, destabilization of the stream channel, loss of riparian cover both in the torrent course and downstream, and streambed agradation. The lower mainstem of the Kilchis has recovered substantially from the Tillamook Burn and salvage logging, which caused the channel to widen in order to accommodate the sediment load moving down through the system.

Instream Enhancement Sites

Thom and Moore (1997) of ODFW surveyed the Tillamook Basin and produced a prioritized list of instream habitat enhancement sites (Table 3-4). Also included in the report is a map of the riparian sites that could have riparian hardwood conversion projects performed; these sites are listed in the riparian chapter. The following table from Thom and Moore (1997) presents the instream sites for the Kilchis watershed.

Sites were selected for enhancement through the following process:

- stream segments were classified as to gradient and size,
- streams with width 12–20m and gradient less than 2% were selected for very large woody debris placement or boulder weirs,
- information on salmon distribution and migration barriers was evaluated;
- site access was evaluated,
- whether the stream had a habitat survey,
- channel constraint, and
- habitat quality and whether the stream is in a core area[4] (Thom and Moore 1997).

[4] Core Areas are reaches or watersheds within individual coastal basins that are judged to be of critical importance to the sustenance of salmon populations that inhabit those basins. Core areas for coho salmon and steelhead are thought to include habitat suitable to support spawning, summer rearing and winter rearing for those species. Core areas for chinook and chum salmon only represent areas where high density spawning occurs. For these species, therefore, rearing areas are defined as the entire streams and estuary downstream of the spawning areas.

Table 3-4. Potential instream enhancement sites for the Kilchis watershed

Stream Segment	Length ft/m	Channel Width	Priority	Habitat Survey	Field Verified	From	To*
L S Fk. Kilchis	10496 3200	4–12m	1	Y	Y	Sam Downs Ck	TJ on left T1NR9W13
Clear Ck	2898 884	12–20m	2	Y	Y	Mouth	2nd bridge
Clear Ck	8126 2477	4–12m	2	Y	Y	2nd bridge	TJ on left T1NR9W3
Coal Ck	6611 2015	4–12m	2	N	N	mouth	diversion dam
Fick Ck	1283 391	4–12m	2	N	Y	mouth	400m
Kilchis Trib #1	2722 830	4–12m	2	N	N	mouth	ODF boundary
Kilchis Trib #1	373 114	4–12m	2	N	N	ODF boundary	upstream 100m
L S Fk Kilchis	6487 1978	12–20m	2	Y	Y	Iris Ck	S Downs Ck
Murphy Ck	2734 834	4–12m	2	N	N	mouth	Kilchis River Rd
N Fk Kilchis	6914 2108	4–12m	2	Y	Y	Triangulat. Ck	Kilchis River falls
Company Ck	1529 466	4–12m	3	N	Y	mouth	500m
S Fk Kilchis	3488 1063	4–12m	3	Y	Y	Fitch Ck	1st TJ left T1NR8W9
Sam Downs Ck	6206 1892	4–12m	3	Y	Y	mouth	Anns Ck
Schroeder Ck	3128 954	4–12m	3	N	Y	French Ck	lft TJ T2NR8W19
S Fk Kilchis	20139 6140	4–12m	3	N	Y	Company Ck	Fitch Ck
Triangulat Ck	1137 347	4–12m	3	N	Y	mouth	350m
N Fk Kilchis	4164 1270	12–20m	4	Y	Y	Fossil Canyon	Triangulat. Ck
Schroeder Ck	6271 1912	12–20m	4	N	Y	mouth	French Ck

Note: Priority: 1 high, 2 medium, 3 low, 4 very low. *TJ—tributary junction

Source: Thom, B. and K. Moore. 1997. North Coast Stream project: Guide to Instream and Riparian Restoration Sites and Site Selection (Kilchis, Miami, Lower Nehalem, Tillamook, Trask, and Wilson River Drainages). 38 pp.

4.0 RIPARIAN

Introduction

Riparian vegetation provides several functions in a healthy ecosystem. These include: moderating water temperature by providing shade in the summer and thermal cover in the winter; acting as a filter to prevent heavy sediment loads from entering the water; stabilizing stream banks to prevent erosion; and providing LWD to the streams for habitat diversity. This section covers:

- degraded riparian stands,
- riparian shade evaluation,
- riparian large woody debris supply potential,
- the location of current riparian enhancement projects,
- potential riparian restoration sites.

Degraded Riparian Stands

The ODFW stream habitat surveys (GIS layer Kilhab) gives information regarding the riparian vegetation within sample plots spread throughout the watershed (84 sample plots). The 30m by 5m plots were laid out perpendicular to the channel on both sides and spaced every 30 habitat units. The information was divided into left bank and right bank riparian vegetation. In addition, the surveys gathered information that characterized the riparian vegetation within one ACW of the channel along all surveyed reaches.

The surveys divided the vegetation into eight categories. Using the survey codes, three ratings were developed: “missing”, “degraded”, and “better” with regard to the ability of the vegetation to provide shade and be a source of LWD. Table 4-1 lists the survey codes and corresponding ratings used on the riparian condition map (Figure 4-1).

Table 4-1. Survey codes and ratings used on the riparian condition map

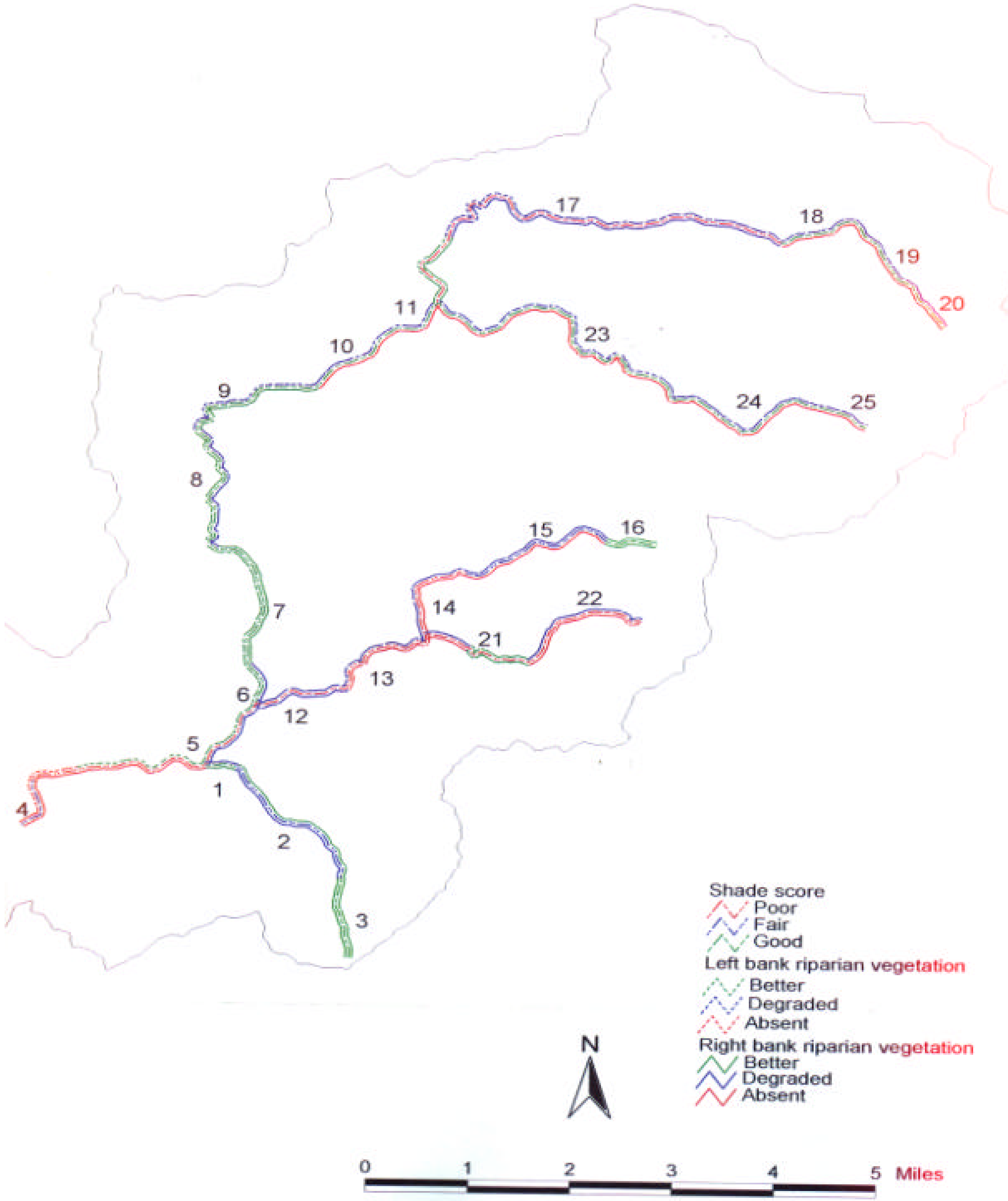
Survey code	Rating
N - No vegetation	**Absent** (unable to provide adequate shade, thermal cover, or LWD)
B - Sagebrush	
G - Annual Grasses, herbs, and forbs	
P - Perennial grasses, sedges, and rushes	
S - Shrubs (willow, salmonberry, some alder)	
D - Deciduous dominated (canopy more than 70% alder)	**Degraded** (able to provide shade in the summer, but unable to provide LWD or persistent thermal cover in the winter)
M - Mixed conifer/deciduous (50/50 distribution)	**Better** (able to be a source of LWD, able to provide shade in the summer and persistent thermal cover in the winter)
C- Coniferous dominated (canopy more than 70%)	

Source: Survey codes only from ODFW (Oregon Dept. of Fish and Wildlife). 1995a. Aquatic Inventories Project Physical Habitat Surveys: Kilchis and Tillamook River Basins.

The riparian condition map shows these ratings as the two outer lines of the three on the map, representing the left and right banks. The center line shows the shade rating for the stream. Shade ratings and riparian condition are used to identify potential restoration areas later in this chapter.

Fourteen percent of the surveyed riparian stands are of better quality on both banks, while 52% are degraded on one bank and 3.3% are degraded on both banks. In combination with the degraded LWD recruitment ratings this indicates that Kilchis watershed streams tend to be deficient in large coniferous or deciduous/coniferous mixed forest in the riparian zone.

In an attempt to prioritize the restoration of riparian vegetation, the ability to shade the stream was evaluated (Figure 4-1). Data collected in the ODFW stream survey was rated using the ODFW benchmarks to produce these shade scores (Table 3-3). For a complete discussion see the next section. When riparian bank vegetation and shade scores were compared, trends and discrepancies appeared.



'igure 4-1. Riparian characteristics for the surveyed reaches of the Kilchis River. (Source: TBNEP GIS layer KILRCH)

Three areas, reaches 3, 7, and 16, received both “good” shade scores and “better” riparian vegetation scores. Reaches 6 and 8 above and below reach 7, also received good shade scores and at least one bank had good riparian vegetation ratings. Reaches 6, 7, and part of 8 are located in Kilchis County Park and are relatively protected. It is suggested that reaches 3–16 also receive protection from further degradation as desirable conditions already exist. Protecting existing habitat should have the highest priority for two reasons: first it appears that there is very little high quality habitat remaining for salmon, and secondly, protecting habitat is much less costly than restoring habitat.

Reach 4 shows poor riparian vegetation on both banks as well as fair shading. HOBO temperature monitors upstream from this area indicate that water temperatures are already warmer than preferred for some salmon species (See HOBO5 on table 6-3). This area should be evaluated as a priority for restoration. This area falls on private land and will require that landowner incentives be developed for effective restoration to occur.

As mentioned earlier, some discrepancies in riparian vegetation and shade ratings appeared. The South Fork of the Kilchis (reaches 23, 24, and 25) and the upper extreme of the North Fork (reaches 8, 19, and 20) received good shade scores, but these areas had absent and/or degraded riparian vegetation scores. This could be a result of a heavy, low shrub community that does well shading, but provides little thermal cover and no LWD potential.

Some riparian alder conversion work has been completed on the North Fork of the Kilchis (reach 17) (Figure 4-2). These projects were located in areas where shade scores were poor and riparian habitat was degraded. In general, areas that receive poor shade scores and have at least one bank with poor riparian vegetation should be examined as potential riparian enhancement sites. For example, one area to examine is on the Little South Fork (reaches 14 and 15), where shade scores are low, right bank vegetation is rated as absent, and left bank vegetation is rated as degraded.

Riparian Shade Evaluation

The ability of the riparian stands to provide adequate shade to the streams was evaluated for the 25 stream reaches covered by the ODFW stream habitat surveys (Figure 4-1). The “open sky” measurement in the Kilhab database was used to determine the amount of shading; if there is no shading the reading is 100 and if there is total shading the reading is 0. This measurement has the following drawbacks: the orientation of the stream is not taken into account (a north-south orientation would allow more sunlight to reach the stream than an east-west orientation would with the same amount of vegetation); the measurement involves observer bias and therefore is not that repeatable (Robison, G. personal communication 1998).

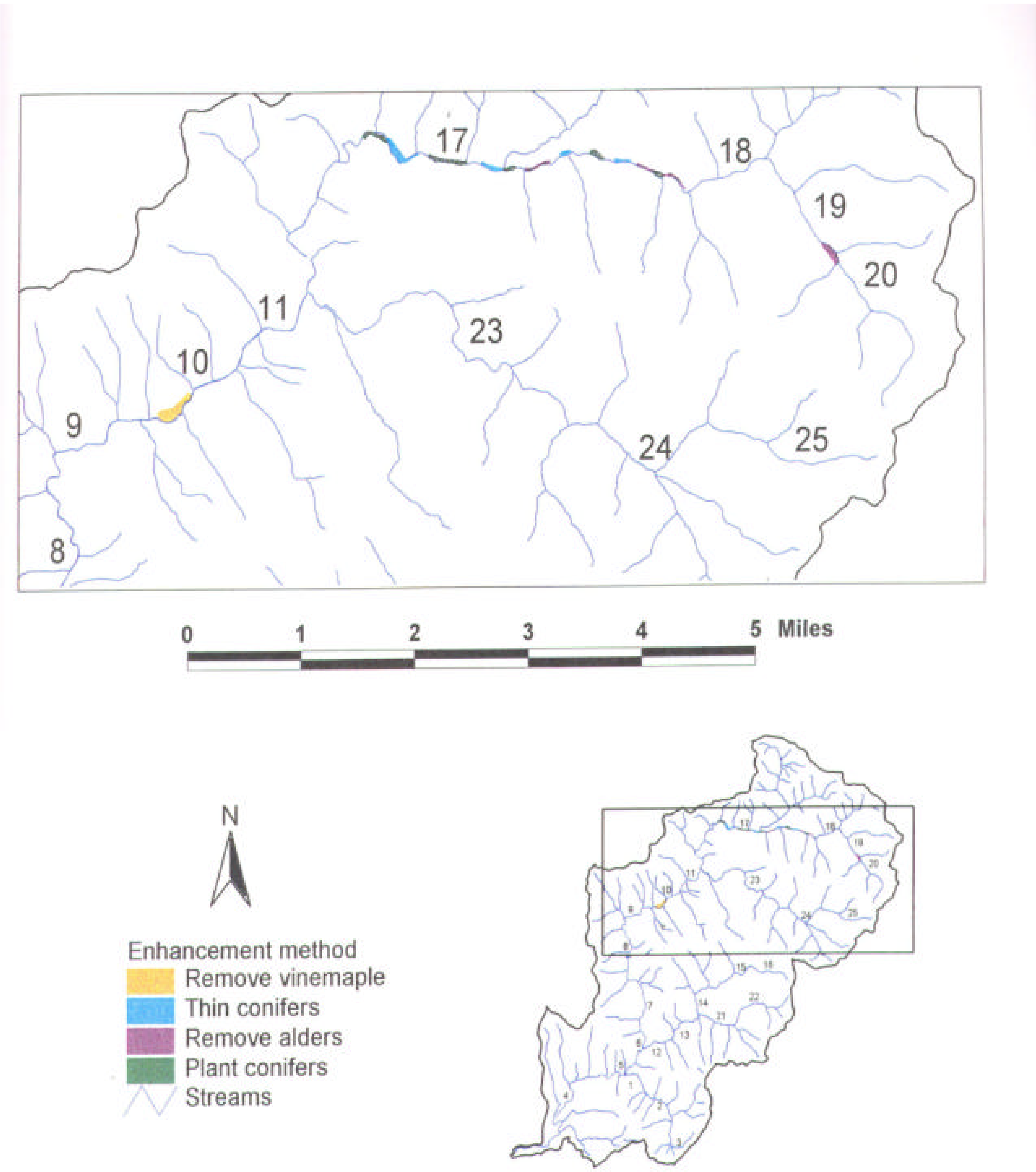


Figure 4-2. Riparian enhancement projects undertaken by Oregon Department of Forestry. (Source: Dutton, S. 1997. ODF, Regeneration Forester. Personal communication, TBNEP GIS shapefile ALDER)

The ODFW shade benchmarks for coastal streams require at least 70% shading on streams with an active channel width of 39 feet or less and at least 60% on channels greater than 39 feet in width. Streams were rated good if they were at or above the benchmark figure, fair if they were within 20% of the benchmark, and poor if they were more than 20% below the benchmark; Table 3-2 presents all of the habitat quality benchmarks. Figure 4-1 presents the shade ratings for all of the habitat units (approximately 1850 Habitat Units [HU]) surveyed.

Kilchis Mainstem

The mainstem had poor and fair ratings in the lower two reaches (Reaches 4 and 5) respectively (Table 3-3), and good ratings in the upper six reaches (Reaches 6–11; see Table 3-3 for the average rating by reach).

Clear Creek

Clear Creek had good and fair ratings throughout all three reaches (Reaches 1–3).

Little South Fork

This fork had poor ratings in the lower three reaches (Reaches 12–14), and fair and good ratings in the upper two reaches (Reaches 15 and 16) respectively.

Sam Downs Creek

Sam Downs had poor ratings throughout the two reaches (Reaches 21 and 22).

North Fork

This fork had a poor rating for the first reach (Reach 17), and good ratings for the three upper reaches (Reaches 18–20). Reach 20 will probably decline over the next few years to a fair or poor rating as the riparian stands are impacted by bank erosion from the debris flow on a tributary.

South Fork

This fork had good ratings throughout all reaches (Reaches 23–25).

The 92 perennial tributary streams not included in the ODFW habitat survey were qualitatively evaluated using a 1995 ODF aerial photo set. The riparian stands on tributaries are primarily composed of dense alder stands with occasional conifers visible in the canopy. There were no riparian stands found on tributaries that provided inadequate shading to the stream channel, except for occasional short sections. Very seldom can the stream be seen through the canopy on the aerial photos; this indicates an average canopy closure of greater than 90%. The summary qualitative rating of tributary streams based on the 1995 photo set is that the riparian stands are providing adequate shade for all streams. However, an undetermined number of these streams (including French Creek, Upper North Fork Kilchis, and several tributaries to South Fork) were severely impacted by debris flows caused by the February 1996 storm with resultant reduction of riparian shading. As the bedload from these debris flows moves downstream causing bed agradation, bank erosion, channel widening, and additional loss of riparian stands, there will be additional losses of riparian shading in the reaches to which these streams are tributary.

The overall status of riparian shading of streams in the surveyed reaches of the Kilchis watershed is mixed, with 25% of the samples rated as poor, approximately 20% rated as fair, and 55% rated as good. Of the riparian sample points that received good ratings, 36% of the sample points had completely closed canopies providing 100% shade, while another 36% had dense canopies providing at least 80% shade.

Based on the ODFW stream habitat surveys, the problem areas to be prioritized for riparian enhancement are the entire surveyed portion of Sam Downs Creek, the lower reach of the North Fork, the lower two reaches of the mainstem, and the lower three reaches of the Little South Fork. Additional enhancement projects are needed on the streams that recently experienced debris flows. The reaches below the torrent-impacted reaches will have their riparian stands impacted by channel widening and bank erosion over the next few years.

Riparian Large Woody Debris Supply Potential

The ability of the riparian stands to provide adequate LWD to the streams in the future was quantitatively evaluated for 84 sample points (belt transects 30m by 5m perpendicular to the stream with one for each bank) in the 25 surveyed stream reaches. The data collected in the sample plots includes species and diameter of all trees, and canopy closure. The plots were rated either good, fair, or poor for their future ability to supply LWD to the stream using the evaluation method presented in the manual titled *Standard Methodology for Conducting Watershed Analysis* (Washington Forest Practices Board 1993). The method bases the rating on stand composition, size/age of the trees, and stand density measured as canopy closure; the rating parameters are presented in Table 3-2 (presented as LWD Recruit. Potential).

Of the 84 sample points, 81 received a poor rating, one received a fair rating, and two received good ratings (Figure 3-2). The fair and good points were on the main stem of the Kilchis (reach 6) in areas where there were some residual large trees that boosted their ratings. In general, the surveyed reaches were dominated by alder and were rated low to very low in conifers. The size/age of the trees was rated as young for 82 of the 84 samples and mature for the remaining two samples. The stand density was rated sparse for a little over half of the points and dense for the remainder.

The 92 perennial tributary streams that were not included in the ODFW habitat survey were qualitatively evaluated using aerial photos, although the results were a general rating for all the tributaries rather than a tabulation by individual streams. The riparian stands on tributaries are primarily composed of alder stands with occasional conifers apparent in the canopy. The size/age of the trees is comparable to the stands on the surveyed reaches which were rated as young. The stands are almost all dense with only occasional small areas that would be rated as sparse. Based on this qualitative evaluation, the tributaries would all be rated poor because of the lack of conifers and the small average size of the riparian trees.

The poor ability of riparian stands to supply high quality LWD to the stream channels means that for the foreseeable future the channels will lack habitat complexity provided by LWD, will have a lowered ability to sort and store sediment, and will not be able to reduce the power of the stream through increasing the roughness and complexity of the channel. The result is continued low habitat quality in many reaches, low sediment storage and accelerated transport of the bedload, and continued high energy flows with great erosive power.

Location of Current Riparian Enhancement Projects

Typically in riparian enhancement projects the goal is to create a vegetative community that can provide shade to the stream and eventually provide large decay-resistant wood to serve as LWD in the stream when it dies. LWD serves to: control the flow of debris and gravel, as cover and protection for fish, and as a nutrient source for small aquatic invertebrates. In northern Oregon coastal streams, the vegetation community that can best meet those requirements is a coniferous or mixed coniferous and deciduous forest. Conifers grow to larger diameters and decay slower instream than deciduous trees. The riparian enhancement typically happens in one of three ways: planting of conifers among existing vegetation, thinning existing conifers to promote fewer but larger trees, and removing alders or other deciduous vegetation that may be shading out coniferous saplings. The latter is referred to as a “conifer release,” as it releases the conifers from deciduous competition to grow to larger sizes.

In recent ODF riparian enhancement projects, over 20 acres of riparian area have been altered in some way to remove alders and establish or enhance conifer growth. Figure 4-2 shows the approximate (digitized from hand-drawn estimates) location and size of the riparian areas and the type of work done. A summary of the acreages and project type is shown in Table 4-2. Much of the riparian work has been done on the North Fork of the Kilchis River (Figure 4-2).

Table 4-2. Riparian conversion projects and the acreage of completed projects of each type in the Kilchis Watershed

Conversion type	Acres
Re-establish conifers among current vegetation	~9
Thin conifers to promote growth	~10
Remove alders (“Release”)	~2

Source: Dutton, S. 1997. ODF, Regeneration Forester. Personal Communication.

Through comparison of project locations with areas of quality fish habitat, it is apparent that most of the projects are located in upland forested areas containing existing high quality fish habitat. This will lead to further enhancement and protection of the habitat, which is already the best the watershed has to offer. In the future as the trees mature and add to the large woody debris available, the LWD will better control landslide debris that may enter the stream further protecting and enhancing fish habitat.

In order for fish to migrate to the upland areas, they must first pass through very degraded habitat in the agriculture dominated portion of the watershed. In the future, lowland areas should also be considered when riparian habitat work is allocated to bring these areas up to at least moderate quality fish habitat so that it does not prevent fish migrations to the upstream areas.

Potential Riparian Restoration Sites

As part of a comprehensive GIS analysis of the potential for instream enhancement work in the North Coast Basin, ODFW biologists also completed a cursory evaluation of potential riparian restoration sites (Thom and Moore 1997). The process used to identify reaches for potential riparian restoration was: overlay GIS coverages for streams and vegetation types, identify sites that are dominated by small to medium hardwoods, and select those sites that are located on streams chosen for instream enhancement projects or directly downstream. The riparian sites were not prioritized and will be listed from the top of the watershed to the bottom.

- North Fork Kilchis River—from Kilchis Falls to confluence with South Fork (Reaches 17–20).
- French Creek—section in middle reach of stream, section just above confluence with Schroeder Creek.
- Schroeder Creek—section in upper reach, section just above confluence with French Creek, reach from confluence with French to confluence with North Fork.
- South Fork Kilchis—from upper reach to confluence with Company Creek (Reaches 14–16).
- Company Creek—lower reach to confluence with South Fork.
- Mainstem Kilchis—majority of reach from North and South Fork confluence to confluence with Tilton Creek (Reaches 8–11), scattered sections in the reach from confluence with Tilton Creek to confluence with Little South Fork.
- Tilton Creek—short section in lower reach just above confluence with mainstem Kilchis.
- Little South Fork Kilchis—majority of upper reach ending at confluence with Sam Downs Creek, majority of reach from confluence with Sam Downs to confluence with mainstem Kilchis.
- Sam Downs Creek—lower half of creek to confluence with South Fork Kilchis.
- Clear Creek—lower two thirds of creek to confluence with mainstem Kilchis.
- Murphy Creek—short section above confluence with mainstem Kilchis.
- Kilchis Tributary 1—lower reach above confluence with mainstem Kilchis.
- Coal Creek—lower half to confluence with mainstem Kilchis.
- Mainstem Kilchis—scattered short sections from just above confluence with Murphy Creek to mouth.

5.0 Erosion

Introduction

The major concern with erosion from a watershed perspective is its effects on beneficial uses both within and downstream of the watershed. The natural background level of sediment is necessary for the functioning of channel forming processes and maintenance of instream habitat. The negative effects of increased sediment generation include: fine sediment deposition in spawning gravels that can smother salmonid eggs, reduce intergravel oxygen, increased turbidity in the water column that can interfere with sight-feeding by salmonids, direct burial of macroinvertebrate insects and their habitat, and bed aggradation throughout the stream network including accumulation of sediment in low gradient channels causing bank erosion and impairing navigation. This section covers:

- erosion setting and landslides on forest lands;
- erosion timing, sediment size, and delivery to streams;
- erosion volume estimate;
- erosion background levels;
- shallow, rapid landslides risk;
- causes of shallow, rapid landslides;
- deep-seated landslides;
- erosion of fine sediment from roads;
- erosion on abandoned roads; and
- sediment reduction efforts.

Erosion Setting and Landslides on Forest Lands

Most of the Kilchis watershed is steep and rugged. Hillslope steepness commonly exceeds 35 degrees (70%). Landslides are the dominant natural erosional process on these steep forested slopes, and occur most frequently after intense winter rains, or extended periods of precipitation. Most landslides in the Kilchis watershed originate as shallow translational (debris) slides from the steep hillslopes. Such landslides, as they move downslope, may accumulate additional soil, water and LWD and behave as flows or torrents. Slumps and earthflow type landslides are less common in the Kilchis watershed, as are the infrequent but very large structural/rock failures (a 500,000 cubic yard rock failure occurred in the Wilson River watershed in 1991).

Management of the Kilchis watershed can affect the volume of sediment produced, the size of that sediment, and the routing of that sediment through the watershed to the bay. Historically, the greatest source of increased sediment was a series of intense forest fires known as the “Tillamook Burn”. Landslides and surface erosion increased dramatically after these fires and subsequent timber salvage operations.

Although surface erosion in the upper watershed is a less important source of erosion as compared to landslides, it still is very important in some cases. Surface erosion under natural forest cover in the maritime Pacific Northwest is unusual, except adjacent to channels. Forest roads, compaction of forest soils, and forest fires increase the likelihood of surface erosion. Surface erosion tends to be dominated by movement of smaller sized sediment (sands and silts). Surface erosion is also driven by hydrologic events (rainfall, sometimes including rain-related snowmelt). Road drainage can contribute to both surface erosion and landslides.

Landslides occur most frequently after intense winter rains. A landslide is the movement of soil, rock, and/or debris downslope; the most common type in steep forest lands is referred to as debris slides. A debris slide is relatively small and shallow, with typical dimensions of 3 feet in depth, 30 feet in width, and 40 feet in length with a relatively planar failure surface (same shape as the ground surface). In steep terrain, small shallow landslides can quickly transform into debris flows. A debris flow occurs if the landslide moves downslope as a semi-fluid mass scouring or partially scouring soils from the slope along its path. Debris flows may increase in size as they move downslope and commonly transport many times more sediment than the initiating landslide. In some cases, an initiating landslide of 10 cubic yards or less may become a debris torrent moving thousands of cubic yards of material into and through channels.

Forest practices may alter both physical and biological (vegetative) slope properties related to slope stability. Physical alterations can include slope steepening, slope water effects, and changes in soil strength. Most of the physical alterations are caused by haul roads and skid roads. Roads have by far the greatest effect on stability of slopes on forestlands, at least on a unit area basis (Sidle *et al.* 1985). Roads alter slope steepness, soil strength, and pore water pressure within a slope, the three most critical parameters affecting slope stability.

Vegetation has a subtler and yet still significant effect on the stability of slopes (Greenway 1987). Hydrologic effects of vegetation include: interception (storage of water on leaves and branches) or evapotranspiration (removal of water from the soil or vegetation by plant growth or climate); and creating macropores (natural pipe-like structures common in forest soils). Mechanical effects of vegetation include: root reinforcement (where roots have penetrated into a potential landslide surface and added to strength); buttressing and arching (where trees at the base of a potential landslide act like piles); surcharge loading by trees, logs and debris (where the weight of these materials may add to the gravity force on the slope); wedging and loosening of soil by roots; and windthrow (as trees blow down soils are displaced and oversteepened, and also vibrated). Tree removal can have the following effects on soils: a reduction in interception or evapotranspiration, altering macropores, a reduction in the soil infiltration rate, alteration of snowmelt patterns, reduction in root reinforcement, and loss of buttressing and arching.

Erosion Timing, Sediment Size, and Delivery to Streams

Table 5-1 gives qualitative estimates for different types of erosion of when sediment is generated, what type of material makes up the sediment, and what proportion of the sediment generated ends up in streams. The table is meant to put the different types of erosion in perspective since the timing, type of material, and the proportion delivered to streams are very important in determining the impacts on fish habitat.

Table 5-1. Timing of generation, occurrence, particle size range, and delivery to streams of sediment generated from different sources

Parameter Source Type	Timing of Sediment Generation	Occurrence	Particle Size Range of Sediment	Source % Delivered to Streams
Shallow, Rapid Landslides	rainy season, episodic	many in large storms	complete spectrum	high percentage
Deep-seated Landslides	rainy season	rare, can be very large	complete spectrum	moderate percentage
Road Surface Erosion	continuous when water is in road ditches	early rain, or mod/hvy rain	primarily fines	moderate to low percentage
Road Drainage Structure Erosion	rainy season	high flows, heavy traffic	mostly fines, but complete spectrum	high percentage
Upland Surface Erosion	after fires or dry ravel	after fire or heavy rain	mostly fines	moderate to low percentage
Lowland Bank Erosion	high flows or cattle accessible	high flows, direct disturbance	mostly fines	very high percentage

Source: Mills, K. 1997. Forest roads, drainage, and sediment delivery in the Kilchis River watershed. Prepared for: Tillamook Bay National Estuary Project, 48 pp.

There were 57 shallow, road-related landslides in the Kilchis watershed during the winter of 1995–96, of which 48 involved more than 10 yd^3 volume.[5] Additional landslides occurred in harvest units and timber stands. Of the 48 larger landslides, 45 were due to failure of fill material and the other three were due to failure of the cutslope. Twenty-nine of the large landslides entered stream channels, while another ten may have entered channels. The total volume of landslides that may have entered channels was 5400 yd^3 (excluding debris flows), with the largest landslide having a volume of 710 yd^3. Less than 20% of the landslides occurred on slopes of less than 70%. Forty-five (94%) of the landslides were caused by a failure of fill materials along a road, and thirty-one of these landslides were not associated with road drainage waters.

No deep-seated landslides were reported for the winter of 1995–96. Road surface erosion was not measured, but the sediment budget has the range of 100 to 5000 yd^3 for road erosion during an extreme storm such as the one in February 1996.

The road survey found 50 road drainage structure washouts from the 1995–96 winter; of these 22 resulted in greater than 10 yd^3 volume of erosion (Mills 1997). Twelve of the large washouts occurred at stream crossings, while the other 10 were associated with water diverted down roads. Total sediment delivery to streams from large washouts was 3700 yd^3, with 2425 yd^3 of this resulting from a single washout on Sam Downs Road.

Sediment resulting from road surface erosion consists primarily of the fine soil that washes off of road surfaces due to rain and vehicle traffic. Approximately 96% of the roads in the Kilchis watershed are surfaced with dirty rock (contains significant fine grained material) and the remaining 4% are dirt surfaced (Mills 1997). Approximately 39% of the road lengths have no ditches, which means that a significant portion of the forest roads have water flowing along the inside edge of the road instead of in a ditch. If there was an increase in road traffic due to increased harvest operations or other road uses, the surface erosion would also increase unless additional measures were taken to control erosion and road drainage.

There is no quantified estimate of the volume of sediment generated by lowland bank erosion. The two lowest reaches of the Kilchis that were included in the ODFW stream habitat survey had active erosion on 29% and 11% of the banks (ODFW 1995).

Erosion Volume Estimate

Mills (1997) presents a partial sediment budget for a normal year, a major storm and an extreme storm. The sediment sources included in the table are road surface erosion, road washouts, road landslides, abandoned road landslides, and background landslides (no human inputs, includes deep seated landslides). The sediment sources not included in the table are soil creep, streambank erosion, and the effects of fire or earthquake.

[5] All of the quantified estimates of erosion in this section are taken from the ODF study titled *Forest Roads, Drainage, and Sediment Delivery in the Kilchis River Watershed* (Mills 1997).

Erosion Background Levels

The partial sediment budget (Table 5-2) for the forested portion of the Kilchis includes an estimate of the background level of sediment generated by natural erosion. The quantity of sediment produced is dependent on the intensity of storms in a given year and ranges from a low of 100–1000 yd^3 in a normal year, to 1000–100,000 yd^3 from a major storm, to a high of 100,000–500,000 yd^3 from an extreme storm. Two reasons that the background levels are so high for major and extreme storms are: 1) the coast ranges are young and have very steep topography, and 2) random events are included such as large, deep-seated landslides.

Table 5-2. Sediment source breakdown for the Kilchis watershed

Source Type	Normal Year	Major Storm	Extreme Storm
Road Surface Erosion	50–500 yd^3	50–1000 yd^3	100–5000 yd^3
Road Washouts	100 yd^3	2500 yd^3	25,000 yd^3
Road Landslides	2000 yd^3	20,000 yd^3	200,000 yd^3
Abandoned Road Landslides	0 yd^3	5000 yd^3	100,000 yd^3
Background Landslides	100–1000 yd^3	1000–100,000 yd^3	100,000–500,000 yd^3

Source: Mills, K. 1997. Forest roads, drainage, and sediment delivery in the Kilchis River watershed. Prepared for: Tillamook Bay National Estuary Project, 48 pp.

The sediment budget is considered partial because it does not include figures for:

- soil creep,
- stream bank erosion,
- dry ravel,
- stream channel agradation or degradation,
- lowland agricultural sources,
- rural residential area sources, and
- non-forest roads of the watershed.

Agricultural sediment includes minor sources such as fine sediment production off of farm roads, farmyards, and tilled fields, and the potentially larger source of accelerated streambank erosion due to livestock trampling. Rural residential sediment includes fine sediment production from development activities and road runoff. Non-forest road sediment includes washouts and landslides caused by roads, and sediment generated by road maintenance and repair activities. No estimates for sediment generated by these sources was found for this watershed.

Shallow, Rapid Landslide Risk

The risk of shallow, rapid landslides occurring is highest in areas with slopes greater than 70% for most geologic formations, except Tyee, where 60% slopes are considered high risk (Mills, K. personal communication 1997). The area covered by the slope class of >70% is estimated to be close to 50%. These areas include many small, very steep headwater areas of tributaries known as headwalls, which concentrate subsurface water due to their topography. The combination of subsurface water and steep slopes makes the headwalls very prone to shallow, rapid landslides.

Causes of Shallow, Rapid Landslides

Mills' analysis (Mills 1997) assumes that the 57 landslides of 1995–96 is typical of what would occur in the Kilchis watershed due to any major storm during a period of relatively low road building and timber harvesting activities. In an area of steep slopes such as the Kilchis watershed, landslides are the dominant erosional mechanism (Mills 1997). Landslides are mass movements of unsorted soil, rock and vegetation due to shear failure occuring on a surface or combination of surfaces (Mills 1997). The surface may be the soil/rock interface or the junction between two soil layers where the lower layer is less permeable to water; both situations cause a concentration of water at the interface between the layers. Several causal factors for shallow, rapid landslides that are pertinent to the Kilchis watershed are: failure of road fillslopes, loss of slope stabilization by tree roots, topographic concentration of subsurface water; a factor enhancing all of these causes is slope steepness. These causal factors are discussed in the following paragraphs.

Road construction on steep slopes requires excavation into the slope and further steepening of the cutslope. Traditionally, the excavated material was pushed onto the downhill side of the road creating a fillslope, which is much steeper than the native slope prior to construction. Any time the slope angle is increased through cutting or filling, the stability of the slope is decreased and the probability of landslides occuring is increased (Mills 1997). A recent change to the Oregon Forest Practice Act (FPA) rules requires the offsite removal of this fill material (called endhauling) when landslides and channel damage are likely, rather than its disposal on a fillslope. This recent change in the forest practice rules will reduce the incidence of cutslope failures on new forest roads, but existing roads and legacy roads will continue to cause landslides of this type. Failures of the fillslope are more likely than cutslope failures to become debris flows (Mills 1997). Almost all major road-related landslides (delivering sediment to streams) investigated by the ODF are related to road sidecast (uncompacted material pushed onto the fillslope) or road fills (Mills 1997). Of the 48 large landslides during winter 1995–96 in the Kilchis watershed, 45 landslides or 94% were failures of fill materials on forest roads (Mills 1997). Twenty-nine of the landslides definitely entered channels, while another ten may have entered channels and nine definitely did not enter channels (Mills 1997); this underscores the connection between forest roads and debris flow generation. The total volume of landslides that entered or may have entered stream channels was 5400 yd^3 (see debris flows discussion).

Another type of landslide that is associated with clearcuts is due to the loss of tree root stabilization of slopes. This type of landslide occurs approximately five to seven years after a clearcut when the roots of the harvested trees decay. The roots are no longer stabilizing the slope at that point and when the subsurface soil conditions reach a saturation point at a surface (bedrock, impermeable soil layer) a landslide may occur. These landslides would probably not occur otherwise because of the stabilizing influence of live roots. This type does not appear to be occuring in the Kilchis watershed at this time, but it is likely to begin occuring several years after the onset of clearcut logging in the Kilchis.

There is a background level of shallow, rapid landslides that are not associated with human activities. These result primarily from topographic concentration of subsurface water at an impermeable surface (bedrock, impermeable soil layer) that results in a landslide. When subsurface water is concentrated on very steep slopes it causes a landslide; this erosion is a normal component of the steep, coastal mountains that comprise the Kilchis watershed. No numbers are available on the background rate or sizes of natural landslides in the Kilchis watershed.

A factor which enhances all of the causes of shallow, rapid landslides is steep slopes. The number of landslides from the winter of 1995-96 occuring in the different slope classes are: 50–60% (1), 60–70% (6), 70–80% (21), 80–90% (10), 90–100% (9), and >100% (1). This shows that 84% of the landslides occurred on slopes of 70% or greater. The other area of concern on lesser slopes is the Tyee formation, which has an elevated risk of landslides on slopes greater than 60% (Mills, ODF personal communication 1997).

The primary cause of shallow, rapid landslides in the Kilchis watershed at this time is road fillslope failure, followed by the natural topographic concentration of subsurface water. If large scale logging were to begin again, then slope failure due to loss of root stabilization would again become important while road related failures would probably continue at a gradually declining rate. The background level of naturally occuring landslides is assumed to be fairly constant, but some human-induced landslides occur on the same sites thus precluding the natural slides.

Deep Seated Landslides

Deep seated landslides occur in situations that are predisposed to this type of mass failure due to a combination of geologic, morphologic and topographic factors. They are triggered by heavy rains and are considered to be rare events. Their size can be very large due to being caused by a deep seated structural failure, but only a moderate percentage of the material they generate actually is delivered to stream channels (Mills 1997). When deep seated landslides do reach a stream they often create a debris dam, which may cause a long-lasting change in the channel such as the creation of a productive flat. No deep seated landslides have occurred in the recent past in the Kilchis watershed and there is no way to predict when the next one will occur.

Erosion of Fine Sediment from Roads

The Kilchis watershed has approximately 107 miles of drivable or walkable (moderately overgrown) forest roads, with the majority of the roads having been constructed between 1920 and 1970. All of these roads were evaluated for erosion potential in 1995–1996 for the study titled *Forest Roads, Drainage, and Sediment Delivery in the Kilchis River Watershed* (Mills 1997). The field survey evaluated general road characteristics, the condition of the road in locations where sediment is generated between discharge points, specific locations of surface water discharge such as culverts, cross drains, and water bars, and potential for delivery of sediment directly to streams. Figure 5-1 is a GIS map of the roads and drainage structure locations identified in the survey.

The primary road erosion problems exclusive of landslides, which are treated elsewhere, are: 1) the excessive length of ditches that route sediment laden waters directly to stream channels, and 2) the number of steep gradient (over 13%) road segments with excessively spaced cross-drainage structures (Mills 1997). These factors relate to the delivery of water-transported eroded material from the ditches directly to streams, and the downcutting of roadside ditches.

The average length of road segments to the first cross-drainage structure above a stream crossing was 436 feet, while average cross-drainage structure spacing for the entire Kilchis forest road system was 381 feet (Mills 1997). The lengths represented by these two measures indicate that road ditches were designed to get the water off the road efficiently and into a stream channel. Current forest practices (enacted in the last 25 years) require that the muddy water in road ditches be directed to the forest floor to be filtered before it reaches a stream channel.

The road survey found that 25% of the total length of road segments definitely deliver sediment directly to streams through culverts or ditches that connect to stream channels; an additional 14% were given a possible direct delivery rating (Mills 1997). The remaining 61% of road surfaces drain to the forest floor either from an outsloped road surface or through having their drainage ditch runoff directed to the forest floor. Sediment in the runoff from these segments is largely filtered out by the forest floor before it can reach stream channels. The Kilchis watershed has the same proportion of forest roads draining directly to streams as the 39% average for western Oregon found in a random survey of road erosion conducted by ODF (ODF 1996).

Mills (1997) was unable to make direct measurements on the sediment generated by surface erosion of forest roads in the Kilchis watershed. A survey of the literature indicated that in coastal Oregon areas with stable, low traffic roads with vegetated cut slopes and ditches built on comparable soils over similar geologic formations, the annual road surface erosion was equal to one kilogram per meter of road length per year. For the Kilchis sediment budget, Mills used a range of one to ten kilograms of sediment per meter of road per year in a normal year; this translates to a range of 50 to 500 yd^3 per year for the watershed as a whole (see Table 5-2). Since no sampling of road surface sediment occurred, there are no data on the particle size range for sediments generated by road surface erosion.

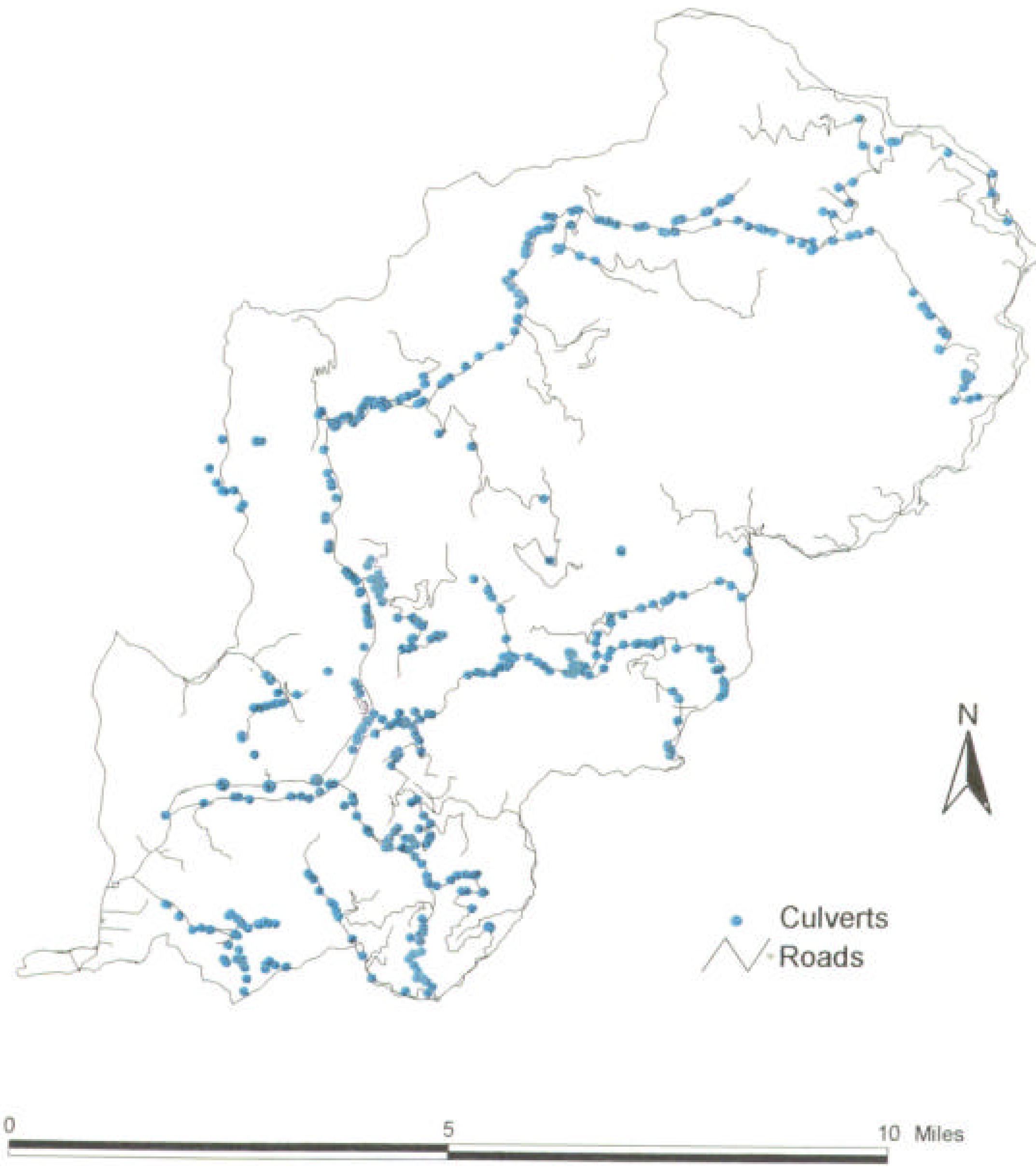


Figure 5-1. Culverts in the Kilchis watershed. (Source: TBNEP GIS layers KILGPS, KILNOGPS)

The erosional processes on road running surfaces (road tread area) are more continuous in nature rather than episodic like landslides. This means that for a given type of road surface, surface erosion is somewhat proportional to the quantity of use (number of miles driven) and type of use (light vehicles vs. logging trucks). The remaining factor is the type of surfacing and how it breaks down over time and with use. At present, the number of miles driven on Kilchis forest roads is relatively low and the type of use is primarily light vehicles, so that running surface erosion is a minor component of the overall sediment budget. In the future, the Kilchis forest road system will experience heavy log truck use as harvest levels increase. Increased harvest levels will proportionately increase erosion of the running surface—possibly by a factor of two or more (Mills 1997).

Erosion on Abandoned Roads

The partial sediment budget (Table 5-2) presents information on the erosion and sediment associated with abandoned roads in the Kilchis watershed. The quantity of sediment produced is dependent on the intensity of storms in a given year and ranges from a low of 0 yd^3 in a normal year, to 5000 yd^3 from a major storm, to a high of 100,000 yd^3 from an extreme storm. These figures represent 0% of the partial sediment budget for a normal year, 6.4% of the budget for a major storm, and 15.9% for an extreme storm (computed from the mean of the range for each value in the partial sediment budget).

The figure of 0 yd^3 in a normal year is due to two factors. The first is that if a road is not driven, then there is no disturbance and thus no erosion of fine material from the surface. The second factor is vegetative stabilization of the cut- and fillslopes over time. The majority of erosion on cut- and fill-slopes occurs in the first couple of years following construction (Mills 1997). If there is no disturbance of these slopes through use or from runoff being directed over them, then there is no surface erosion.

The figures for a major storm of 5000 yd^3, and for an extreme storm of 100,000 yd^3 are due to fillslope failure causing shallow, rapid landslides, or plugged/collapsed culverts causing major washouts. The legacy roads were constructed to standards that are no longer legal in Oregon under the current FPA. Excavated material was pushed over the side as sidecast or compacted to fill a portion of the running surface. This construction method results in steeper slopes that are more prone to failure than native slopes. Major and extreme storms create the conditions that can trigger the failure of these over-steepened fillslopes and produce shallow, rapid landslides. There is also a higher probability of old stream crossing structures (cedar puncheons, culverts) becoming plugged during these storms because they are not regularly maintained on abandoned roads, and these storms move more solid material (*i.e.*, leaves, branches, soil and rock) in surface flows than occurs in normal years.

These figures indicate that abandoned roads are not a problem in normal years, but with increasingly severe storms the abandoned roads contribute a significant portion of the overall sediment budget.

Sediment Reduction Efforts

Sediment reduction efforts take several forms in the forested uplands of the watershed. ODF evaluated all forest roads on their land in the Kilchis Watershed using the Forest Road Hazard Inventory protocol. This resulted in a prioritized list of road upgrade projects that seeks to address sediment generated by this source. The activities include: decommissioning legacy roads that have a high probability of failure, replacement of culverts that have a high probability of failure, installation of additional cross-drains so that road drainage is filtered across the forest floor instead of being routed directly to a stream, placing clean rock on roads that are not surfaced, and replacing undersized or damaged culverts that could plug during a storm. At present there is no comprehensive program on private forest lands in the Kilchis to accomplish these sediment reduction activities.

Bank erosion is the major source of sediment in the floodplain portion of the Kilchis Watershed. Currently there is a program run jointly by the NRCS and SWCD to: fence pastures along streams and plant riparian vegetation on the banks; build livestock bridges across streams; and pave cow lanes. This is a voluntary program and due to limited availability of cost-share funds, there is a waiting list. A few projects have been completed in the Kilchis Watershed, but many more miles of banks need to be fenced on the mainstem and its tributaries in the floodplain.

6.0 WATER QUALITY

Introduction

Water quality is an important issue for both humans and wildlife in that it potentially affects all uses of the water. Impacts to water quality can range from excessive suspended solids loads, to temperature extremes in salmonid habitat, to bacteria and nutrient contamination from the agricultural and residential portions of the watersheds.

This section includes:

- water temperature exceeding salmonid habitat requirements,
- water contaminants other than bacteria,
- bacterial contamination of surface waters, and
- the location of residences on private septic systems.

Water Temperature Exceeding Salmonid Habitat Requirements

Several areas show potential salmonid limitations due to stream temperature at some point during the spawning, incubation, or rearing part of the fish life cycles. Additionally, the Kilchis River is identified as a water quality impaired stream by the Department of Environmental Quality (DEQ). This is discussed further following the discussion of salmon habitats. Each of the five salmonid species present in the Kilchis watershed will be discussed separately following the general discussion.

Twelve HOBO monitors were placed in the Kilchis watershed (Figure 6-1) to sample water temperatures during 1995 and 1996. The monitors measured and recorded water temperature five times daily. The data is incomplete in that it was not recorded for all months in a year at all sites. Table 6-1 shows the months recorded at each site and in which salmon habitat each monitor was located. For example, information from Monitor 3 was complete only for October through May and no information was available for June through September. Where data was available for the same month in two years, the average values were taken of maximum, minimum, and average temperatures. Table 6-2 lists preferred temperature ranges by species that were used in determining the ratings used in Table 6-3. The table codes can be explained as follows:

- A temperature rating of good indicates that all temperatures during the months examined were within the preferred range of temperatures for that species (as determined by a literature survey).
- A temperature rating of poor indicates that at least one temperature during the months examined fell outside the preferred range by *more than one degree* (either hotter or cooler).
- A temperature rating of possibly poor indicates that the trends in the months before and after indicated that most likely temperatures would be out of the preferred range, however no data are available to support this directly.
- A temperature rating of lethal indicates that temperatures were recorded that were higher than the reported lethal temperature for that species.

For example, the months that spring chinook are spawning in north coast streams are September through October. At Monitor 1, the following maximum temperatures for the two months were recorded at 16.91°Celsius (C) and 13.44°C, respectively. The preferred range for spring chinook during spawning is 5.6°–13.9°C. The October reading is within range, however the September reading is beyond the range by more than one degree. Therefore a poor rating for maximum temperature would be given for Monitor 1 during spawning months for spring chinook.

Some general trends become apparent from a temporal and spatial examination of the data. Monitor 12 very often recorded temperatures that are beyond the preferred range for fish. Similarly, Monitors 2, 3, and 4 often recorded temperatures beyond the preferred range. When such factors as shade scores, riparian health, and woodscores are examined above Monitor 12 possible explanations become apparent. Figure 4-1 shows degraded or absent riparian habitat for most of the stream above Monitor 12. Figure 4-1 also shows poor ratings for shade for several miles upstream from Monitor 12. Figure 6-2 shows a rating category called “woodscore”, which measures the degree of wood complexity instream. This category was determined using the Kilhab database, which was compiled from the 1995 ODFW habitat surveys. The area above Monitor 12 (reaches 17–20) shows a very low woodscore rating ranging from 1 to 2. The “woodscore” range is from 1 (wood debris absent or in low abundance), to 5 (wood present as large single pieces, accumulations, and jams that trap large amounts of additional material and create a variety of cover and refuge habitats).

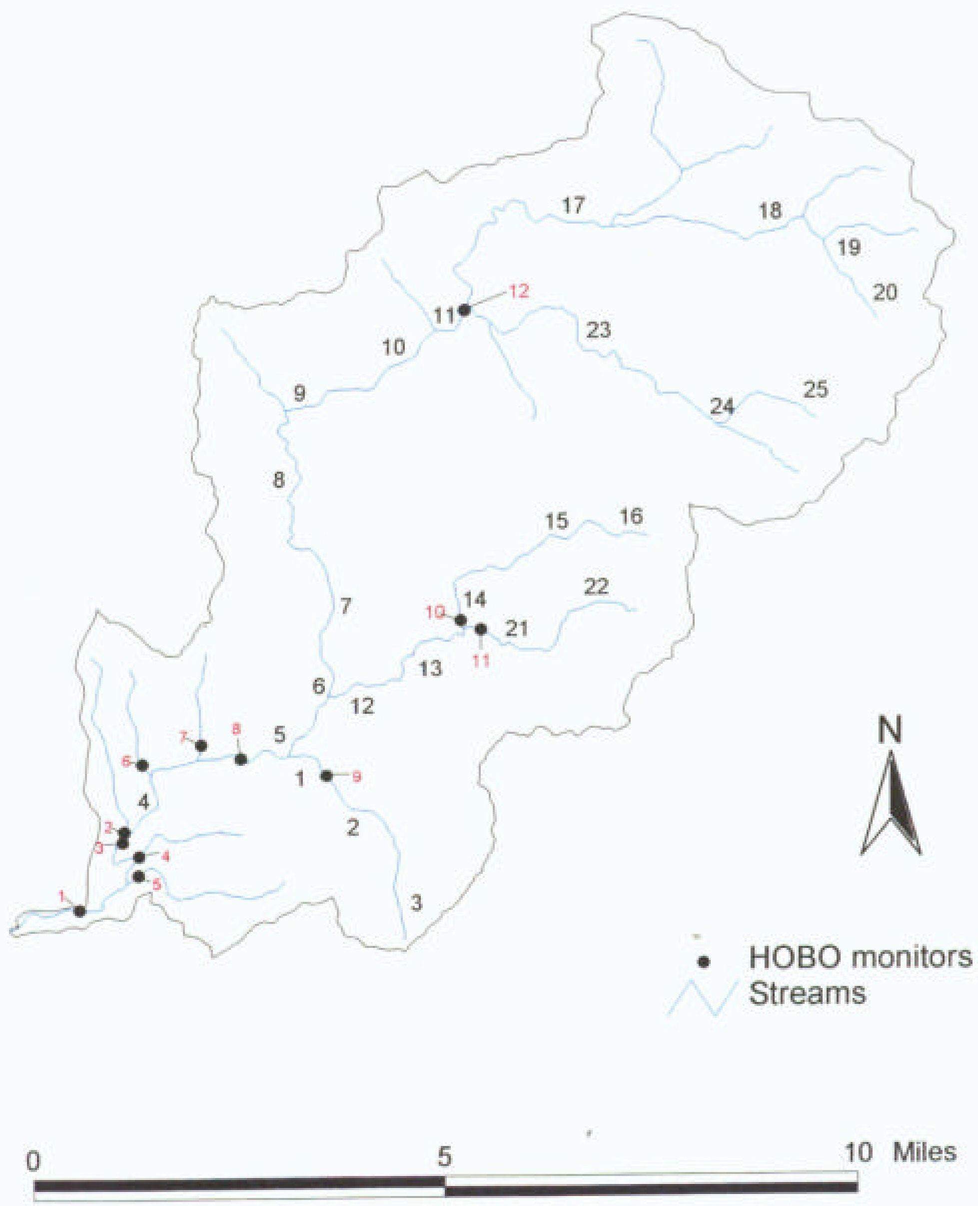


Figure 6-1. Location of HOBO temperature monitors in the Kilchis watershed in 1996.
(Source: TBNEP GIS layer HOBO)

Table 6-1. Location, period of record, and salmonid habitat information for the 12 HOBO monitors in the Kilchis watershed

Hobo	Location	Period of data recorded (months)		ODFW Reach #	Located in the habitat of:					
		1995	1996		Fall chinook	Spring chinook	Chum	Coho	Winter steelhead	Summer steelhead
1	Mainstem		Apr.–Jan. '97	n/a	x	x	x	x	x	x
2	Murphy Creek		Jan.–Oct.	n/a	x		x	x	x	
3	Mainstem	Oct.–Dec.	Jan.–May.	n/a	x	x	x	x	x	x
4	Unnamed Tributary	Dec.	Jan.–Oct.	n/a			x			
5	Coal Creek	Dec.	Jan.–May.	n/a			x	x		
6	Mapes Creek		Mar.–Oct.	n/a			x	x		
7	Myrtle Creek	Dec.	Jan., Mar.–Oct.	n/a		x	x		x	
8	Mainstem		Jan.–Oct.	5	x	x	x	x	x	x
9	Clear Creek		Jan.–Oct.	2	x	x	x	x	x	s
10	Little South Fork	Dec.	Jan.–Oct.	14	x	x		x	x	x
11	Sam Downs Creek	Dec.	Jan.–Oct.	21	x	x		x	x	s
12	Mainstem	Dec.	Jan.–Oct.	11	x			x	x	x

Source: Stinson, R. 1996, 1997. Tillamook Soil and Water Conservation District, Hydrologist. Personal communications.

Table 6-2. Life stage timing and water temperature requirements of salmonids (in degrees Celsius)

	Months	Average Temp	Maximum Temp	Minimum Temp
Fall chinook				
spawning	Oct–Jan	5.6–13.9		
incubation	Nov–May	5–14	20; lethal 25.2	4.4; lethal 0
rearing	Mar–June	7.3–14.6	20; lethal 25.2	7.3
Spring chinook				
spawning	Sept–Oct	5.6–13.9		
incubation	Sept–Mar	5–14	20; lethal 25.2	4.4; lethal 0
rearing	Feb–June	7.3–14.6	20; lethal 25.2	7.3
Coho				
spawning	Oct–Jan	4.4–14		
incubation	Oct–June	4–13	20; lethal 25.8	4.4; lethal 0
rearing	One year	11.8–14.6	20; lethal 25.8	11.8
Chum				
spawning	Nov–Dec	7.2–12.8		
incubation	Nov–Apr	4–13	20; lethal 25.8	4.4; lethal 0
rearing	Mar–Apr	6.7–14.6	20; lethal 25.8	6.7
Winter steelhead				
spawning	Jan–May	3.9–9.4		
incubation	Jan–June	4–13	20; lethal 25.8	4.4; lethal 0
rearing	Year(s)	7.3–14.6	20; lethal 24.1	7.3
Cutthroat				
spawning	Dec–Feb	6.1–17.2		
incubation	Dec–May	6.1–17.2	20; lethal 23	6.1; lethal 0
rearing	Year(s)	9.5–12.9	20; lethal 23	9.5

Sources: Emmett, R. L. , S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume II: Species life history summaries. ELMR Rep. No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD, 329 pp.

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Nickelson, T., J. Nicholas, A. McGie, R. Lindsay, D. Bottom, R. Kaiser, and S. Jacobs. 1992. Status of anadromous salmonids in Oregon coastal basins. Oregon Dept. Fish Wild. Corvallis, OR.

Reiser, D.W. and T.C. Bjornn. 1979. Habitat Requirements of Anadromous Salmonids. In W.R. Meehan (editor), *Influences of forest and range land management on anadromous fish habitat in western North America*, U.S. Forest Service General Technical Report PNW-96, Pacific Northwest Forest Range Experiment Station, Portland, OR.

Table 6-3. Temperature conditions for salmonid spawning, incubation, and rearing in the Kilchis watershed. HOBO monitors record temperatures 4 times daily. Monthly minimum, average, and maximum temperatures were noted. Temperatures must exceed the preferred range by more than one degree to merit a poor rating.

Spawning

HOBO	Fall Chinook Spawning			Spring Chinook Spawning			Chum Spawning			Coho Spawning			Winter Steelhead Spawning			Cutthroat Spawning		
	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum
1	✓	✓	✗	✗	✓	✓	✓	✓	✗	✓	✓	✓	✗	✗	▼	✓	✓	✗
2	✗	✓	✗	✗	✓	✓	·	·	·	✗	✓	✗	✗	✗	✓	✓	✓	✗
3	✗	✓	✗	✗	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	✓	✓
4	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✓	✗
5	✓	✓	✓	·	·	·	✓	✓	✓	·	·	·	✗	✗	✓	✓	✓	✗
6	·	·	·	✓	✓	✓	·	·	·	·	·	·	✗	✓	✓	·	·	·
7	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✗
8	✓	✓	✗	✗	✓	✓	·	·	·	✗	✓	✓	✗	✓	✓	✓	✓	✗
9	✓	✓	✗	✓	✓	✓	·	·	·	✓	✓	✓	✗	✓	✓	✓	✓	✗
10	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗
11	✓	✓	✗	✓	✓	✓	·	·	·	✓	✓	✓	✗	✓	✓	✓	✓	✗
12	✓	✓	✗	✗	✓	✗	·	·	·	✗	✓	✗	✗	✓	✣	✓	✓	✣

Incubation

HOBO	Fall Chinook Incubation			Spring Chinook Incubation			Chum Incuabation			Coho Incubation			Winter Steelhead Incubation			Cutthroat Incubation		
	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum
1	·	✓	✓	✓	✓	✓	✗	✓	▼	✗	✗	✓	✣	✗	▼	✗	✓	✗
2	·	✓	✓	✣	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗
3	✓	✓	✓	·	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
4	✗	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓	✗	✗	✓	✗	✓	✓	✗
5	✗	✗	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗
6	✓	✓	✓	✓	✓	✓	▼	▼	▼	✓	✓	▼	✓	✓	▼	✓	✓	▼
7	✓	✓	✓	✓	✓	✓	✓	✓	▼	✓	✓	✓	✓	✓	▼	✓	✓	✗
8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
11	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✗	✓	✓	✗
12	✓	✓	✗	✓	✓	✗	✓	✓	✣	✓	✓	✣	✓	✓	✣	✓	✓	✗

Rearing

HOBO	Fall Chinook Rearing			Spring Chinook Rearing			Coho Rearing			Chum Rearing			Winter Steelhead Rearing			Cutthroat Rearing		
	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum
1	✗	✓	✓	✗	✓	▼	✗	✗	✗	✗	✓	▼	✣	✗	✗	✣	✗	✗
2	✗	✓	✗	✗	✓	✗	✣	✗	✗	✓	✓	✗	✣	✗	✗	✣	✗	✗
3	✓	✓	✗	✓	✓	✗	▼	✗	✗	✓	✓	✗	▼	▼	✗	▼	✗	✗
4	✗	✓	✗	✗	✓	✗	✣	✗	✗	✓	✓	✗	✣	✗	✗	✣	✗	✗
5	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✣	✗	✗
6	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✓	✗	✗
7	✓	✓	✗	✓	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗	✗
8	✓	✓	✗	✓	✓	✗	✗	✗	✗	✓	✓	✗	✓	✓	✗	✓	✗	✗
9	✓	✓	✗	✓	✓	✗	✓	✗	✗	✓	✓	✗	✓	✓	✗	✓	✗	✗
10	✓	✓	✗	✓	✓	✗	✓	✗	✗	✓	✓	✗	✓	✓	✗	✓	✗	✗
11	✓	✓	✗	✓	✓	✗	✓	✗	✗	✓	✓	✗	✓	✓	✗	✓	✗	✗
12	✓	✓	✣	✓	✓	✣	✗	✗	✣	✓	✓	✣	✗	✓	✣	✗	✗	✗

✓ Within preferred temperature range ✗ Outside of preferred temperature range ✣ Lethal ▼ Possibly poor · No data

Monitors 2, 3, and 4 were located in lowland areas. These streams flow through agricultural areas, tend to be slower moving and have very little riparian vegetation along them. This results in high summer temperatures (and consequently lower oxygen content), as well as wide fluctuations in temperatures.

These poor riparian conditions result in inadequate shading in the summer and very low thermal cover in the winter. Additionally poor riparian conditions can result in increased sedimentation to streams, channel widening and shallowing, and poor organic and large woody debris input into streams. All of these conditions combine to make for poor habitat conditions for salmonids.

Fall Chinook

Eight monitors were located within fall chinook habitat (see Figure 6-1 and Table 6-2). All of the monitors reported temperatures that are outside the range of preferred conditions for chinook at some time during the spawning stage and the rearing stage of the life cycle, with temperatures generally being too cold. One monitor recorded freezing temperatures during egg incubation months, which would greatly reduce the survival rate of the eggs in this vicinity.

Spring Chinook

Four monitors were located in this area (see Figure 6-1 and Table 6-2). All monitors reported temperatures warmer than optimum during spawning months. One monitor recorded lethal freezing temperatures at some time in the incubation stage of the life cycle, which would greatly reduce the survival rate of the eggs. All four monitors recorded temperatures outside the range of preferred conditions for the fish at some time in the rearing stage of the life cycle.   In general, rearing temperatures were too cold for spring chinook.

Coho

Ten temperature monitors were located within coho habitat (see Figure 6-1 and Table 6-2). Of those, six recorded temperatures outside the range of preferred conditions for spawning and incubation of eggs. Monitor 12, at the confluence of the North Fork and the South Fork, recorded lethal freezing temperatures several times during egg incubation months. All monitors recorded undesirable average temperatures during the rearing months for juvenile fish. Coho spend up to a year in the streams before smolting and are therefore vulnerable to both very hot temperatures and very cold temperatures. Monitor 2 recorded lethal high temperatures at the mouth of Murphy Creek in July with near lethal temperatures in June, August, and September. All average temperatures for the streams were outside the preferred range; in most cases it was too cold except for Monitor 1, where it was too warm. Note that larger fish can live in temperatures outside the preferred range, however far more damage is done when temperatures are higher than optimum. In optimal cool water, fish populations are generally higher, fish gain weight quicker, and more dissolved oxygen is available (Reiser and Bjornn 1979).

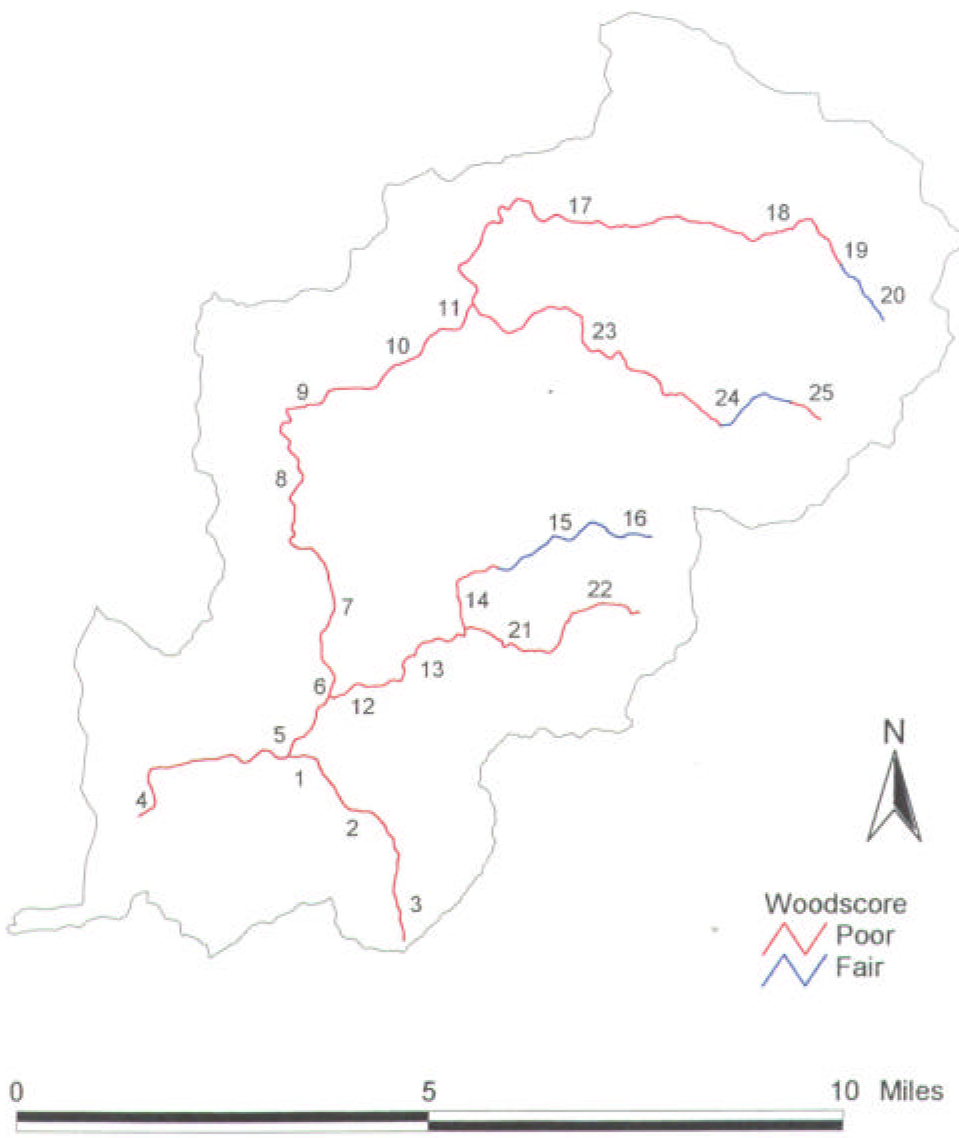

Figure 6-2. Woodscore ratings (a combined rating of LWD characteristics) for the Kilchis watershed. (Source: TBNEP GIS layer KILHAB)

Chum

Nine HOBO temperature monitors were located in the chum habitat (see Figure 6-1 and Table 6-2). Overall *average* temperatures were within the range specified for all life stages. Three monitors recorded temperatures that are colder than the preferred spawning temperatures. Generally, temperatures were too cold for successful development of eggs and growth of juveniles. Five of the monitors reported temperatures that exceed preferred conditions (either too hot or too cold) for the eggs at some time in the incubation stage of their life cycle. Seven of the monitors reported temperatures that are outside the range of preferred conditions for the fish at some time in the rearing stage of the life cycle. Although rearing temperatures were not lethal, according to the literature (Raiser and Bjornn 1979), growth would have been inhibited resulting in fish that are more prone to predation and lower survival rates.

Winter Steelhead

Nine temperature monitors were located within the steelhead habitat (see Figure 6-1 and Table 6-2). All monitors reported maximum temperatures warmer than the preferred range for spawning conditions. Monitors 12 and 7 recorded lethal freezing temperatures, while four others recorded temperatures outside the preferred range for egg incubation. All of the monitors recorded temperatures that were outside the range of preferred conditions for steelhead at some time in the rearing stage of the life cycle including lethal high temperatures at Monitors 1 and 2.

Cutthroat Trout

Most monitors show temperatures that are colder than preferred for spawning conditions for cutthroat trout (see Figure 6-1 and Table 6-2). All monitors recorded temperatures below the preferred egg incubation temperatures and Monitor 1 recorded a high temperature exceeding the preferred range late in the egg incubation season. High temperatures prevent weight gain in fry, making them more vulnerable to predation. Average temperatures during juvenile rearing tended to be on the cold side in winter and spring months and generally good in summer months. There were four lethal high temperature readings at Monitors 1, 2, 4, and 5, as well as a lethal freezing temperature in late winter at Monitor 12.

DEQ Listing

As a result of the Clean Water Act of 1974, the DEQ has maintained a list of Water Quality Impaired streams, called the 303(d) list. The Kilchis River is included in this list because bacteria levels, specifically fecal coliform, do not meet the set standards. The Kilchis River is identified as a Waterbody of Concern with regards to temperature. This could mean that there are insufficient data to list at this time, or that previous data show a trend of impaired temperatures, but more data are needed to confirm that trend.

Water Contaminants Other Than Bacteria

The water quality monitoring progress report (E&S Environmental Chemistry 1997) for the five rivers in the Basin presents results for bacteria, total phosphorus (TP), total nitrogen (TN) and total suspended solids (TSS). Mean values presented in the report are combined for all sampling points on that river and for all samples collected during the period November 25, 1996 through August 6, 1997. The mean TP level for the Kilchis samples was approximately 0.6 mg/L (1.0 mg/L=1 ppm), which was comparable to the mean TP values for the other rivers (Miami and Tillamook) in the Basin with lower nutrient levels. The GWEB TP indicator level is 0.05 mg/l.

The mean TN value for the Kilchis samples was approximately 1.0 mg/L, which is similar to the levels of TN found in all five of the rivers for the same period. A level of 1.0 mg/L is moderate and does not indicate excessive eutrophication in the Kilchis; the GWEB TN indicator level is 0.30 mg/l.

The mean TSS value for the Kilchis samples was approximately 10 mg/L with one extreme sample value of approximately 60 mg/L. The concentrations of TSS show patterns of increasing concentration with flow, but periodic high values occur when a landslide reaches a stream channel and a pulse of fines is flushed through the system. The mean value for the Kilchis was comparable to the Miami, Tillamook, and Trask Rivers, but much lower than the Wilson River.

Sample values for the summer low-flow period were not yet available at this time.

Bacterial Contamination of Surface Waters

The August 1997 water quality monitoring progress report (E&S Environmental Chemistry 1997) for the five rivers in the Basin stated that the Kilchis River consistently has the lowest concentrations of fecal coliform bacteria. Concentrations of fecal coliform bacteria were all below 100 Colony Forming Units (CFU)/100 ml during the sample period November 25, 1996 through August 6, 1997. The site where these samples were collected is near the Highway 101 bridge, which is below much of the agricultural activity in the lower watershed. The sample values at a secondary site at the forest/agriculture interface were all below 35 CFU/100 ml, which reflects the lack of serious bacteria contamination sources in the forested portion of the watershed. Based on this one sampling period, bacteria contamination of the Kilchis River appears to not be a problem as it is with several of the other rivers in the Basin. However, accidental spills of manure or a serious septic failure could contaminate the river for a period after the spill due to the high water table and close proximity of agriculture and rural residential areas to the river and its lowland tributaries.

Location of Residences on Private Septic Systems

The location of all rural residential and farm building complexes is shown in Figure 6-3; there are no residences in the upper 2/3 of the watershed. All private residences in the Kilchis watershed use on-site disposal systems for their waste water. When these systems malfunction, they can become a significant bacteria source if their discharge reaches surface waters.

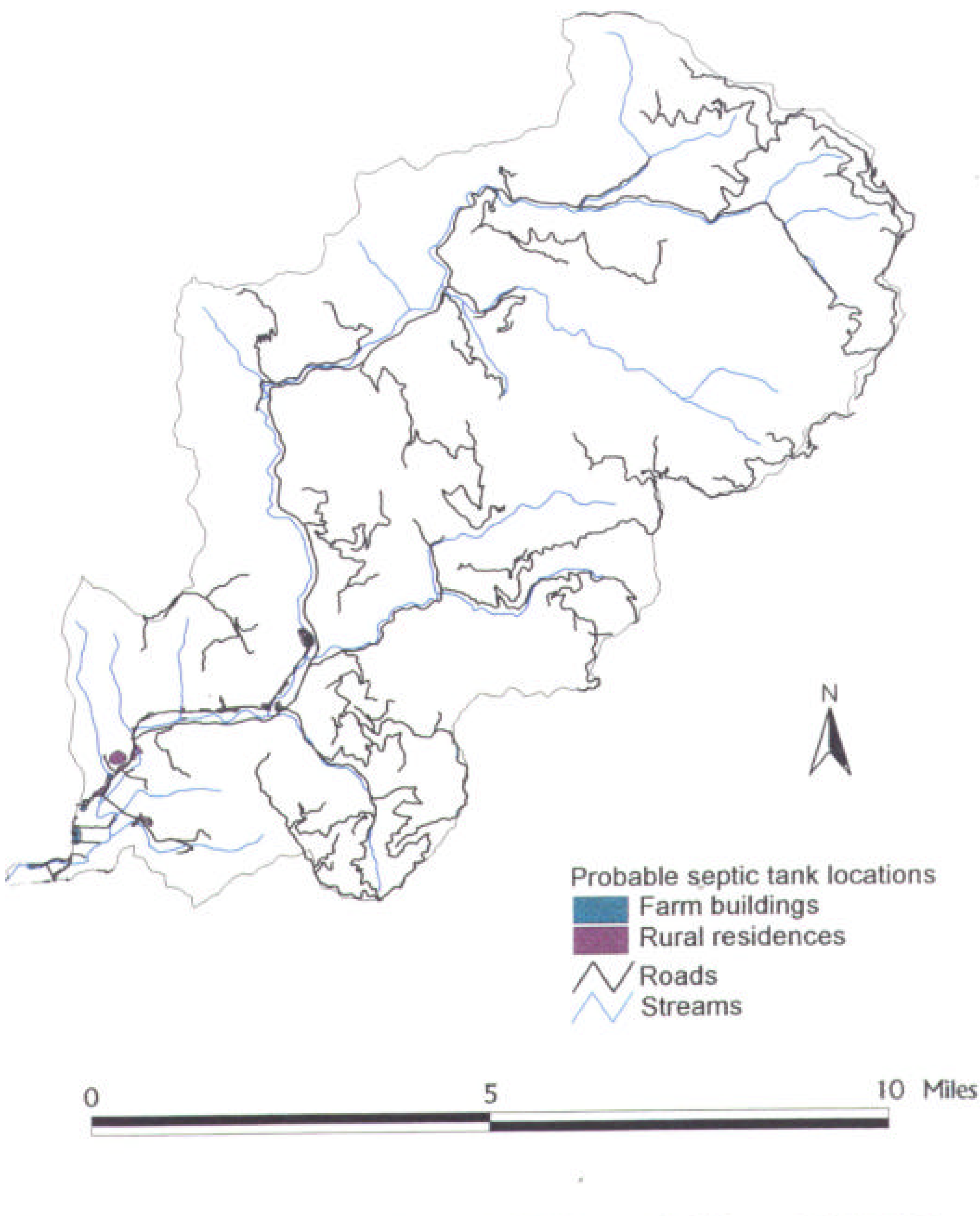

Figure 6-3. Probable septic tank locations in the Kilchis watershed. (Source: TBNEP GIS layer LOWPOLY)

7.0 WETLANDS

Introduction

The coastal plain portions of the Tillamook Basin were formerly dominated by a variety of wetland types. Since the arrival of Euro-American settlers there has been a concerted effort to convert these wetlands to other uses. The current uses are primarily agricultural, residential, and roads.

This section covers:
- conversion of wetlands to other uses,
- national wetland inventory, and
- hydrologic isolation of wetlands.

Conversion of Wetlands to Other Uses

Prehistoric wetlands in the Kilchis Watershed and Tillamook Estuary were extensive and varied. The wetland types consisted of: brush or wooded swamp, grassy swamp, grassy tidal marsh, main valley floodplain bottomland, tidally-influenced forest, and upriver valley timbered floodplain (Coulton *et al.* 1996). Figure 7-1 shows the historic extent of these wetlands as recorded during the land surveys conducted in the 1850s and 1860s (Coulton *et al.* 1996).

Grassy tidal marsh covered all of the delta areas at the river outlets above the high tideline, and below the tideline were intertidal mudflats with eelgrass and algae. Tidally-influenced forest was a riparian type that formed a broad belt behind the tidal marsh in the upper tidally-influenced zone; it was forested with Sitka spruce, western hemlock, western redcedar, bigleaf maple, and red alder. The main valley floodplain bottomland type was the most extensive in the Tillamook Basin and covered all of the lower valley bottomlands with the largest stands in the Wilson, Trask, and Kilchis River valleys. The floodplain tree species were similar to the tidally-influenced forest with the addition of Douglas-fir, crabapple, and an impenetrable understory of various berry species, salal, and vine maple. The upriver valley timbered floodplain was found along all rivers and streams and merged into the general forest with just a change in the proportion of the tree species making up the stands. The common upriver floodplain riparian trees were western redcedar, Sitka spruce, western hemlock, black cottonwood, red alder, Douglas-fir, and crabapple with an impenetrable understory of various berry species, salal, hazelnut, elderberry and vine maple.

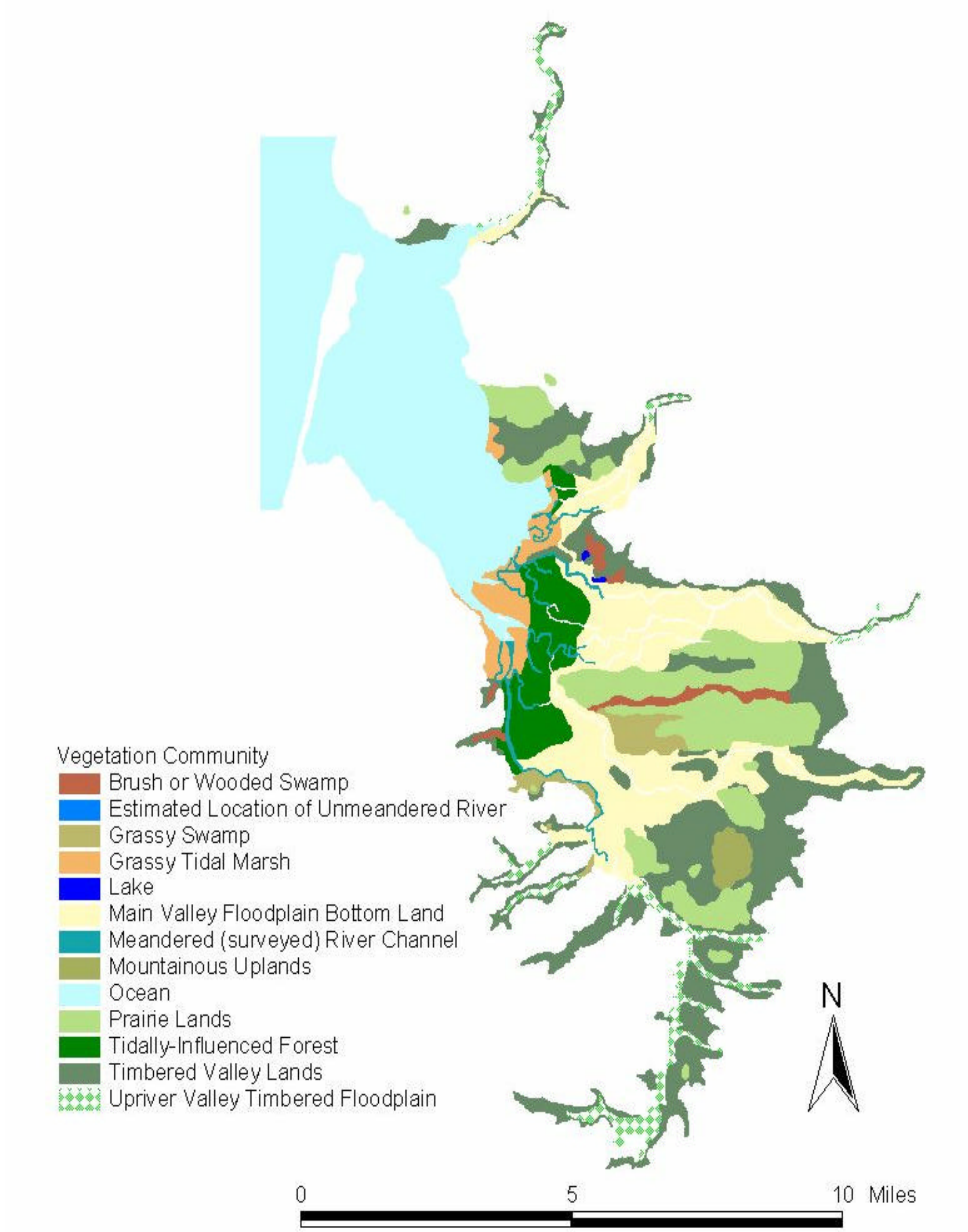

Figure 7-1. Historic wetland communities around Tillamook Bay, circa 1867. (Coulton, et. al., 1996. An Environmental History of the Tillamook Bay National Estuary and Watershed, Philip Williams and Associates and Oregon State University. Prepared for theTillamook Bay National Estuary Project, Garibaldi, OR. 68pp., +Figures, TBNEP GIS layer TILAHIST)

Extensive areas of wetlands have been converted to other uses through diking and draining, vegetative clearing and/or filling. Figure 7-2 shows the approximate extent of wetlands that have been converted to other uses within the Tillamook Basin based on interpretation of 1984 US Geological Service (USGS) topographic maps. The original extent of wetlands in the Basin was approximately 26,912 acres for all types. The current extent of wetlands consists of approximately 3400 acres in the original wetland communities and 221 acres of former agricultural land that is being allowed to revert to wetlands. This conversion rate is approximately 86% for all wetland types in the coastal plain portion of the Basin. The following paragraphs discuss each wetland type, where it has been converted and what the current use of the land is.

The type with the smallest acreage converted is the intertidal mud flats type between the grassy tidal marshes and the estuary. The method of conversion is filling and/or dredging and the places this has occurred are the Garibaldi wharf, the Bay City oyster facility, and the Highway 101 right-of-way at Larson Cove north of Bay City (see Figure 7-2). Grassy tidal marshes have been converted to agriculture through diking and draining. This has primarily occurred in the delta regions of the Kilchis, Wilson, Trask and Tillamook Rivers.

The tidally influenced forest has almost vanished in the Tillamook Basin due to its conversion to agricultural land. Following the establishment of a diking, drainage and tide gate system (as was used for the tidal marshes), these forests were cleared of trees and put into pasture. The soil was very productive due to annual flood inputs of rich soil and the high water table reduced the need for summer irrigation. The Kilchis formerly had a stand of tidally influenced riparian stretching from Vaughn Creek to the main channel (see Figure 7-1).

The riparian floodplain type covering the entire Kilchis valley floor nearly out to the present Highway 101 was converted to agricultural land through clearing of the riparian forest. The same situation occurred in the Wilson and Trask River valleys (compare Figure 7-1 to 7-2). The upland riparian was also cleared from most of the river terraces in the region between Mapes Creek and Clear Creek to convert the land to agriculture. These riparian types required no diking and draining and so were easier to convert to agricultural uses than the lower-lying tidally influenced forest.

From comparing Figures 7-1 to 7-2 it is readily apparent that the vast majority of wetlands in the lowland portions of the Kilchis watershed and Tillamook Basin in general have been converted to agricultural uses. These lands were annually enriched with fertile soil from overbank river flows and are now very productive farmlands. However, their original functions in the landscape such as flood amelioration, sediment traps, bank stabilization, and salmon and wildlife habitat have largely been lost due to their conversion to their present uses.

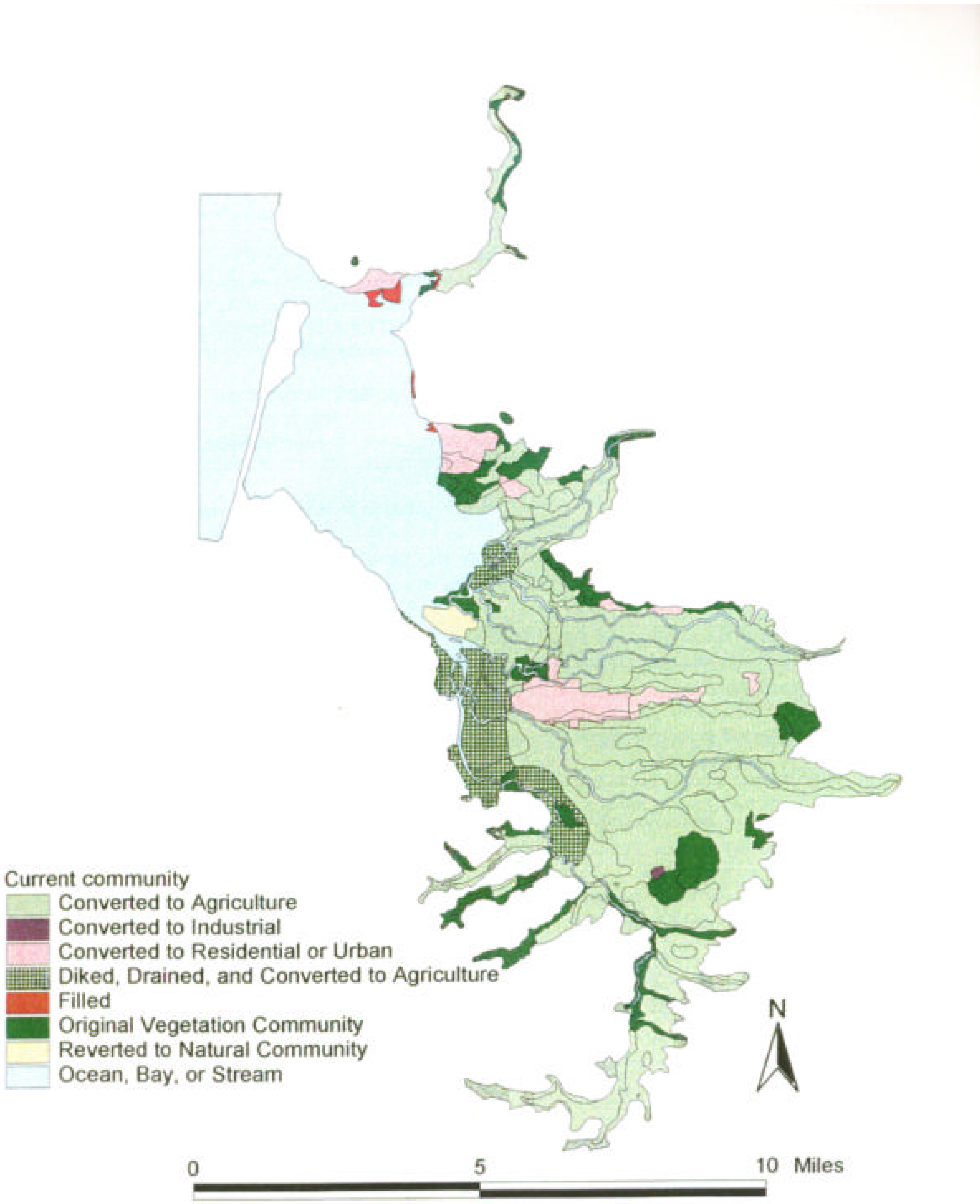

Figure 7-2. Converted wetland areas around Tillamook Bay, 1985. (TBNEP GIS Layer CURWET)

National Wetland Inventory

The remaining wetlands (over 1 acre in size) have been inventoried and included in the National Wetland Inventory (NWI) system run by the United States Fish and Wildlife Service. The digital NWI maps cover only a narrow strip along the coast where the human population is concentrated. For the maps available in digital form, the acreages of each type of wetland have been summed (based on the Cowardin classification) for the Kilchis watershed.

Approximately 5% on the south edge of the watershed is included in the map. Wetlands bordering the estuary are: the subtidal unconsolidated bottom (33.8 acres [ac]). Wetlands in the upland areas are: emergent marsh (35.6 ac), upland riparian (38.5 ac), and upland scrub shrub (0.7 ac). Wetlands along the river are: unconsolidated bottom (11.2 ac), and unconsolidated shore (4.8 ac).

Hydrologic Isolation of Wetlands

Several activities have resulted in the hydrologic isolation of wetlands in the Tillamook Basin. The primary methods have been: diking and draining, levee construction, and road construction.

Diking, Draining and Tide Gates

The delta regions of the bay surrounding the mouths of the five rivers formerly consisted of large acreages of tidal marsh, tidally influenced forest, and floodplain grasslands. Euro-American settlers recognized that these lands would make highly productive pasture lands and began converting them to agricultural uses. Some river and delta islands were diked along their entire shores, but for many riverfront areas it was sufficient to only build a dike along the river edge and install tide gates. Ditches with or without associated tile drains were then constructed in the marshes to collect subsurface and surface water and convey it to tide gates in the dikes. In the Kilchis watershed, Hathaway Slough was diked, ditched, and drained to convert a seasonal marsh to pastureland. Portions of the lower Kilchis main channel and Squeedunk Slough were also diked. It is likely that most dikes and tide gates were installed in the first half of this century as the dairy industry expanded and required the development of marginal lands closer to the estuary. Eventually, the majority of the marshland in the tidal zone was diked and drained.

Tide gates are found in at least 47 locations around Tillamook Bay. The vast majority of tide gates are found on the Tillamook (24) and South Fork Trask (7) Rivers. The remaining tide gates are found on the Bay itself, along the Trask and Wilson Rivers, on Hall and Hathaway Sloughs, and in the Kilchis watershed on Squeedunk Slough.

Tide gates have two primary uses: maintaining diked and drained marshland, and preventing storm-induced flooding. Most tide gates around Tillamook Bay are installed in dikes that prevent tide water from flooding former tidal marshland. The tide gates allow overland flows to enter the rivers or bay at low tide while stopping the return entry of tidal waters at high tide. The drained lands are typically used as pasture. The tide gates installed along Hall, Hathaway, and Squeedunk Sloughs are good examples. Other tide gates, for instance the side-hinged gates at Beaver Creek on the Tillamook River, appear to serve as both tide and storm gates, preventing both tide water and high, rain-induced freshwater flows from affecting the land upstream of the tide gate. In practice, all tide gates also act as floodgates when river levels are high due to runoff.

Tide gates are usually installed as part of a project to convert tidal marsh into relatively dry land that is then used for crops or pasture. The effects of removing vast amounts of tidal marsh from an estuarine ecosystem like Tillamook Bay are severe and long-lasting, but are not all attributable to the tide gates themselves. The loss of such critical habitat would be nearly the same if the diked lands were used as evaporation ponds, as in San Francisco Bay, and no tide gates were installed. When tide gates are installed at the mouths of creeks or large sloughs their effects are more pronounced. Not only is the fringing wetland generally lost, but access by migrating fish to the creek or slough is all but eliminated. Other benefits of the channel, as rearing habitat for salmonids, or as cover from predators or fast currents for fish, are also lost when the tide gate is installed. Tide gates can also cause excessive siltation and clogging of upland channels, requiring periodic dredging to maintain function and associated disruption of the ecosystem.

Levee Construction

The majority of levees were constructed by the COE for flood control. The primary levee systems are surrounding the Stillwell Drainage District island between the Trask and Tillamook Rivers, the levees along both sides of the lower Wilson River, and the levee constructed on the Bayocean Spit to repair the breach. None of these levees affect the Kilchis watershed directly, but through raising flood levels they exacerbate flooding in the lower Kilchis and the rest of the floodplain.

Road Construction

Many of the roads in the lower portions of the Tillamook Basin are constructed on elevated roadbeds because of flooding. The elevated roadbeds bisected some wetlands (*e.g.*, Highway 101 in the Kilchis watershed) and isolated others from the rivers or other source of surface flows. In some cases this has resulted in lower watertables since the surface flow source was cut off and in others it resulted in prolonged ponding due to reduced drainage. The primary impact in the Kilchis watershed has been from Highway 101 through alteration of flood flows and direct burial of seasonal marsh.

8.0 ESTUARY

Introduction

Tillamook Bay is a moderate sized estuary which receives the waters of five rivers and a number of perennial streams. There are many exchanges between the estuary and these waterways including water, biota, and nutrients. The entire estuary is discussed in this chapter rather than limiting the discussion to that portion surrounding the outlet of the Kilchis.

This section covers:

- the status of estuary fish,
- the status of native shellfish,
- the status of oysters,
- the status of shrimp,
- the status of crab species,
- the status of mammal species,
- estuary habitat,
- estuary bathymetry,
- the status of eelgrass, and
- human physical alterations of the estuary.

Status of Estuary Fish[6]

A total of 63 species of fish (including salmonid species) have been identified in Tillamook Bay (Forsberg *et al.* 1975, 1977; Bottom and Forsberg 1978). Of the total, 59 species were collected in the 1974–1976 seine and trawl samples. The species composition of the Tillamook Bay catch was similar to those reported from other Oregon estuaries (Cummings and Schwartz 1971, Pearcy and Myers 1974, Mullen 1977). A few of the rarer species captured in Tillamook Bay were not listed for the other estuaries, including red gunnel, pricklebreast poacher, smoothhead sculpin, and sablefish. In addition, several species commonly reported in other estuaries were not present in Tillamook Bay seine or trawl catches. Bay goby (*Lepidogobius lepidus*) have been reported in Coos Bay and were among the most common larval fishes in Yaquina Bay. Gear selectivity may explain its absence in Tillamook Bay samples. Speckled sanddab (*Citharichthys stigmaeus*) was also found in Coos and Yaquina Bays but absent from the Tillamook Bay collections.

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[6] Sections on fish, shellfish, crabs, and clams largely taken from: Biological Resources, Chapter 3 (TBNEP 1998).

The fish community was dominated by a few abundant species (Table 8-1). The 11 most abundant species caught accounted for 97% of the total catch. Three species—surf smelt, northern anchovy, and shiner perch—represented more than 70% of the entire catch. Nineteen of the species captured were represented by fewer than 10 individuals. Similar fish community structure (*i.e.*, numerical dominance by a few relatively abundant species) also has been found in Yaquina Bay (Pearcy and Myers 1974) and Coos Bay (Hostic 1975).

Table 8-1. Fish species numbers, cumulative percentage and seasons caught per species in Tillamook Bay from 1974–1976

SPECIES	TOTAL #	CUMULATIVE %	SEASONS PRIMARILY CAUGHT			
			winter	spring	summer	fall
Surf smelt	39442	26.5	X	X	X	X
Northern anchovy	35639	50.5			X	X
Shiner perch	31625	71.8		X	X	X
Pacific herring	17114	83.3			X	X
Chinook salmon	6355	87.6			X	X
English sole	6231	91.7	X	X	X	X
Pacific staghorn	3063	93.8	X	X	X	X
Starry flounder	1722	95.0	X	X	X	X
Rockfish spp.	1267	95.8			X	X
Chum salmon	1081	96.5		X		
Saddleback gunnel	1020	97.2	X	X	X	X
Pacific sandlance	765	97.7		X	X	
Buffalo sculpin	740	98.2	X	X	X	X
Threespine	461	98.5	X	X	X	X
Greenling sp.	252	98.7		X	X	X
Bay pipefish	218	98.9	X	X	X	X
Top smelt	192	99				X
Striped seaperch	170	99.1			X	X
Tube-snout	164	99.2	X	X	X	X
Cabezon	159	99.3		X	X	X
Sand sole	125	99.4	X	X	X	X
Coho salmon	114	99.5		X	X	X
Padded sculpin	93	99.5	X	X	X	
Pile perch	80	99.6			X	X
Cutthroat trout	79	99.6		X	X	X
Steelhead trout	75	99.7		X	X	
Prickly sculpin	68	99.7		X	X	
Pacific tomcod	66	99.8			X	
Snake prickleback	61	99.8		X	X	
Lingcod	44	99.9		X	X	

SPECIES	TOTAL #	CUMULATIVE %	SEASONS PRIMARILY CAUGHT			
			winter	spring	summer	fall
Sharpnose sculpin	29	99.9	X			X
PenpoInt gunnel	28	99.9		X	X	
Pacific sanddab	27	99.9			X	X
Tubenose poacher	24	99.9			X	
Red Irish lord	15	99.9		X	X	
Ringtail snailfish	15	99.9+	X	X	X	
American shad	15	99.9+			X	
Walleye surfperch	8	99.9+			X	X
Longfin smelt	8	99.9+		X	X	
White seaperch	7	99.9+			X	X
Tidepool sculpin	6	99.9+	X			X
Redtail surfperch	4	99.9+			X	X
Arrow goby	3	99.9+	X	X		
Silverspotted	3	99.9+			X	X
Red gunnel	2	99.9+		X		
Silver surfperch	2	99.9+				X
Butter sole	2	99.9+		X		X
Brown Irish lord	2	99.9+		X		
Warty poacher	2	99.9+			X	
Slipskin snailfish	1	99.9+				X
High cockscomb	1	99.9+			X	
Pacific lamprey	1	99.9+	X			
Longnose skate	1	99.9+				X
Pricklebreast	1	99.9+	X			
Smoothhead	1	99.9+		X		

Note: Total numbers, cumulative percentage and seasons caught for species collected in all seine and trawl sets in Tillamook Bay, 1974-1976.

Source: Adapted from: Bottom, D. and B. Forsberg. 1978. The fishes of Tillamook Bay. Oregon Dept. Fish and Wildlife, project no. F-100-R. 56 pp.

Abundance of species and individuals showed pronounced seasonality in the 1974–1976 survey (Bottom and Forsberg 1978). Changes in abundance resulted from the loss or gain of transient marine species rather than large scale changes in a resident population. Catch per effort of most species and the number of species per seine and trawl effort generally peaked from May to July. The increase in the number of juvenile herring, surf smelt, English sole, and saddleback gunnel in Tillamook Bay in the spring and summer was consistent with observations of maximum larval abundance of these species in Yaquina Bay (Pearcy and Myers 1974) in the winter or spring.

During the summer, many species were not only more abundant, but were more widely distributed throughout the Bay. Emigration from the Estuary in the fall and winter caused a greater decrease in the catch and number of species per unit effort in the upper Bay relative to other Bay sections. The decreasing abundance of shiner perch, staghorn sculpin, and saddleback gunnel in the upper Estuary in the fall or winter also corresponded to the movements of older individuals into the lower Estuary or ocean.

Since the 1974–1976 fish survey, no additional fish surveys have been conducted in the Bay that allow comparison with present conditions. Therefore, it is not possible to determine whether species composition, relative abundance, or distribution patterns have changed. White sturgeon are also present in the Bay and are increasingly important as a sport fishery (Klumph, R. personal communication 1998).

Herring

Herring were formerly a common species in the bay with substantial numbers spawning in specific areas around the bay through the 1960s (Butler, J. ODFW personal communication 1996). The spawning was concentrated in February and people fished for herring during the period that they were in the Bay for use as bait and for pickling. The spawning areas were located at the Garibaldi boat basin, around Larson Point, Garibaldi Flats, and a large north-south oriented eelgrass bed east of the north half of Bayocean Spit (Oregon Fish Commission 1971). Herring need something to attach their egg masses to such as eelgrass, seaweed, pilings, or large woody debris and these sites provided the necessary structure for egg mass attachment.

In the early 1970s, herring stopped spawning in Tillamook Bay and few have been seen since the mid-1980s. The fishing pressure is not felt to have ben a significant factor in the disappearance of herring from the bay. The most likely factor for their disappearance is changes in their habitat, but since there was no direct monitoring of their populations or habitat there is no data to support this hypothesis (Butler, J. personal communication 1996).

Starry Flounder

Starry flounder were formerly a common species in the Bay during the late winter and into the spring and summer months. In the 1970s, the numbers seen in Tillamook Bay went into a decline and now very few, if any, flounder are found in the Bay. The ocean population of starry flounder has remained stable during the same period, but populations in other coastal estuaries, such as Siletz, Yaquina, and Alsea, have also plummeted during this period. There is a strong correlation between the rise in pinniped use of the bays between the early 1970s and the present and the decline of the starry flounder found in the bays. However, no study was conducted on the populations of the species involved to prove or disprove that pinniped predation was a causal factor in the starry flounder decline (Butler, J. personal communication 1996).

Status of Native Shellfish

Twelve species of bay clams have been collected from Tillamook Bay (Table 3-7) but the most important commercial and recreational species are the gaper, cockle, butter, and native littleneck clams. Cockle clams comprise approximately 90% of the commercial fishery.

The first comprehensive survey of the clam population in Tillamook Bay, conducted between 1974 and 1976, first identified areas of the Bay that had clam population densities that could support commercial harvest (Hancock *et al.* 1979). Additional surveys in 1984 and 1985 covered the same area, and again derived biomass estimates, population composition, and habitat characteristics (Gaumer 1986). In 1995, a partial survey (94 stations) of the lower Estuary was conducted to identify those areas of the Estuary that support relatively dense populations of commercially and recreationally important species of clams (Griffin 1995). This study was followed in 1996 by a more comprehensive inventory of the entire Estuary (Golden *et al.* 1997). In both studies, sampling methods were designed to be consistent with those of the previous ODFW surveys so that data could be directly comparable.

Table 8-2 tracks the densities of the four most important clams in the Hobsonville Channel (an area of high subtidal clam density) over the period 1974–1975 to 1996. Between 1974–1975 and 1996, butter clam abundance appears to have increased dramatically, littleneck clam increased substantially, and cockle clam increased slightly. Gaper clam numbers showed a major decline.

Table 8-2. Density of clams (#/m^2) in Hobsonville Channel

SPECIES	1974–1976	1984	1985	1995	1996*
Cockle	18.6	21.6	28.0	30.7	22.3
Littleneck	15.7	28.1	25.8	12.1	24.6
Gaper	16.4	3.2	4.3	1.7	2.90
Butter	7.9	19.4	31.2	23.9	50.8
Average	14.7	18.1	22.3	17.1	25.20

Note: * Computed as the average of Golden *et al*. sampling sites S2 and S3.
Sources: Griffin, K. 1995. Identification and distribution of subtidal and intertidal shellfish populations in Tillamook Bay, Oregon. Report submitted to the Tillamook Bay National Estuary Project. 68 pp.
Golden, J., D. Gillingham, V. Krutzikowsky, and J. Johnson. 1997. A biological inventory of benthic invertebrates in Tillamook Bay. Oregon Dept. of Fish and Wildlife, Newport, OR. 40 pp. + appendices.

The 1996 clam inventory also compared biomass data from similar subtidal areas (overlapping sample sites) sampled in 1974–1975. In those areas, total biomass of clams in 1996 (320,424 pounds per hectare) was substantially higher than total biomass in 1974–1975 (105,225 pounds per hectare). Cockle clams for areas of overlap had a biomass of 37,381 pounds per hectare in 1996, compared with 26,106 pounds per hectare in 1974–1975. Golden *et al.* (1997) believe the increase in biomass between 1974–1975 and 1996 is largely due to the growth in weight of cockle clams and increased butter clam densities.

Harvest information for the commercial fishery between 1978 and 1994 shows a recent rapid increase in the harvest of cockle clams in Tillamook Bay. Commercial harvest of the three other commercially important species (littleneck, gaper, and butter) remained relatively constant over the same period. Due to concern over the rapid increase in the commercial harvest of cockle clams, the ODFW placed a commercial quota of 90,000 pounds per year beginning in 1995. This quota represents about 10% of the estimated biomass of market-sized clams in the areas that have been surveyed in the past.

The recreational catch of bay clams has not been monitored very closely, thus the number of reliable data points for trend analysis is limited. A detailed study, conducted in 1971, indicated that the total recreational catch for the period March–October 1 was about 60,750 clams from Garibaldi Flats (Gaumer *et al.* 1973–74). Estimates for 1993–1995 on the same area (Griffin 1995), indicate an average of about 13,700 clams. The bag limit in the early 1970s was 36 bay clams versus the present 20 clams, which may account for part of the difference.

Substrate composition appears to be an important limiting factor for cockle, gaper, littleneck, and butter clams. Griffin (1995) indicated that all four species occurred in substrates consisting of the following mixtures: (1) rock and sand; (2) sand and silt; and (3) rock, sand, shell, and silt. Gaumer (1977) noted that substrate in the Garibaldi area of Tillamook Bay consisted of gravel and rock with some shell and sand. This area supported some of Oregon estuaries' heaviest concentrations of intertidal and subtidal bay clams.

Species of clams that are not as commercially or recreationally important generally occur in shallow or intertidal areas characterized by muddy, silty substrate (Griffin 1995). These species include the eastern softshell, bentnosed, irus, and baltic clams. These clams, especially the softshell and bentnosed, can withstand significantly different conditions than the four economically important species, including low salinity, foul substrate, and anaerobic conditions.

Clam populations appear to be negatively affected by the presence of burrowing shrimp. Interactions between clams and shrimp are covered in the subsequent section titled "Status of Shrimp".

Eelgrass may also be a limiting factor for the four economically important clam species in Tillamook Bay. Griffin (1995) found that of 21 stations where eelgrass was present, only five had clams as well. Those five had only gapers and cockles, and always in densities less that $10.8/m^2$. Additionally, at the five stations where eelgrass and clams coexisted, the density of eelgrass was low (always less than 50% cover).

Status of Oysters

Oysters have been grown commercially in Tillamook Bay since the 1930s. Most of the production has been from culture of the Pacific oyster (*Crassostrea gigas*) that was introduced to the United States from Japan in the early 1900s (Quayle 1988). A smaller variety of *C. gigas,* the Kumamoto oyster, was introduced in the late 1940s and early 1950s. The Kumamoto oyster is considered to have better flavor than the larger Pacific oyster but it is more difficult to raise. Small volumes of Kumamoto oysters have been grown in Tillamook Bay but their contribution to total production is inconsequential.

Between 1970 and 1989, total oyster production in Tillamook Bay remained relatively constant with an average annual production of about 21,200 shucked gallons. However, beginning in 1990, production dropped off sharply and has remained very low since that time.

In Tillamook Bay, tideland oyster plots for rearing oysters are leased from the State of Oregon. The current 2,500 acres (1,012 hectares) of leased oyster plots is down from about 3,000 acres (1,215 hectares) that were leased during the 1940s through 1970s. Most of these plots are located west of Bay City in the mid-region of the Estuary.

One of Tillamook Bay oyster growers' primary water quality problems is fecal coliform bacteria in the water column, which periodically exceed federal health standards. Since oysters remove bacteria from the water column, they may represent a health hazard if consumed raw. This has resulted in temporary shutdowns of the Bay's oyster harvesting.

Siltation and increased turbidities over oyster beds resulting from sediment carried into northwest estuaries from tributary rivers and streams can result in high oyster mortalities (Pauley *et al.* 1988, Quayle 1988). This problem represents a continuous threat to Tillamook Bay oyster growers and has caused recurring damages during flood events such as the 1952, 1965, 1972, and 1996 floods. If siltation is severe during floods, it can take several years to get back to full production because oyster culturing requires stabilized substrate. In 1952, Bayocean Spit, the narrow peninsula that separates the ocean from the Bay, breached near the oyster beds. This resulted in a catastrophic sediment event that covered the beds with sand, killing most of the oysters. The breach was repaired in 1956 and oyster production was reestablished.

Other estuarine species reduce Pacific oyster growth or indirectly affect oyster viability. For example, mud and ghost shrimp have caused serious problems for oyster growers in Tillamook Bay. These burrowing shrimp damage oyster beds by making them too soft for culture or by smothering the oysters. This problem was temporarily managed during the 1980s through the use of the pesticide Sevin (carbaryl). Sevin was shown to reduce mud and ghost shrimp populations by more than 90%, which subsequently improved substrate conditions and survival rates for the oysters. However, Sevin is a non-specific pesticide and also killed substantial numbers of other estuarine invertebrates. Due to growing concern regarding the effects of Sevin on the ecology of the Estuary and lawsuits filed by environmental groups, the use of Sevin in Oregon estuaries was terminated in the early 1990s.

A variety of predators are known to eat juvenile and adult Pacific oysters. Those found in Tillamook Bay include: crabs (*Cancer magister, C. productus, and C. gacilis*), the common oyster drill (*Urosalpinx cinerea*), starfish (*Pisaster* spp., *Evasterias troschlii,* and *Pycnopodia helianthoides*), and ducks and scoters.

In summary, many variables influence the success of oyster production in Tillamook Bay. Problems associated with flooding, siltation, bacterial contamination, and burrowing shrimp are relatively obvious. Effects of changes in other variables such as ocean productivity, phytoplankton composition, light penetration, and water temperature are poorly understood.

Status of Shrimp

Two species of burrowing shrimp present in Tillamook Bay are the ghost shrimp (*Callianassa californiensis*) and the mud shrimp (*Upogebia pugettensis*). Both species dig burrows between 10 and 20 inches deep in soft substrates. The ghost shrimp tends to build deeper, more extensive burrows, while the mud shrimp construct less complex, more permanent burrows (Griffin 1997). Both species of shrimp displace large amounts of sediment and are viewed as pests by oyster growers. Burrowing shrimp populations exhibit significant population shifts over time and may show large population increases during El Nino events (Washington Department of Fisheries and Ecology 1985 and 1992 as cited in Griffin 1997).

In a recent study of clam distribution in Tillamook Bay, the presence of shrimp always precluded the presence of clams (Griffin 1995). Of the 92 stations used in the study, 26 had burrowing shrimp present. Of those 26 stations with shrimp, only three also had clams present. The density of clams (10.8 per square meter) at the three stations was the lowest recorded for the study, which ranged from 10.8 to 129 per square meter over the 92 stations (Griffin 1995). Gaumer and McCrae (1990) reported that an increase in the abundance of mud and ghost shrimp on Bayocean Spit in Tillamook Bay during the interval 1975 to 1986 virtually eliminated cockle clams from this once productive area. Similar impacts of burrowing shrimp on clam populations have been observed in other estuaries (*ibid.*). The factors responsible for increases in burrowing shrimp populations are poorly understood.

Status of Dungeness Crabs

The population status of Dungeness crab in Tillamook Bay has not been monitored. The only biological survey data available for Tillamook Bay crab is distribution and relative abundance data collected by ODFW in 1974–1975 (Forsberg *et al.* 1975). During the 12-month study, 5,031 crabs were captured. Crabs were present throughout the entire Estuary but most were captured in the lower third. Legal-size crabs were caught only in the lower and mid-Bay, while sublegal crabs where caught throughout the Bay. The furthest intrusion of crabs into the upper Estuary occurred during the summer and fall, probably associated with low fresh water inputs and subsequent higher estuarine salinity. Most crabs (59%) were captured during the summer and very few (5%) in the winter. Insufficient data are available to evaluate either the present status of Dungeness crabs in the Estuary or trends in their abundance.

Crab surveys conducted between 1983 and 1987 in Washington's Grays Harbor and Willapa Bay and adjacent areas of open coast have shown that coastal crab populations rely heavily on both estuaries as nursery areas (Gunderson *et al.* 1990). Although not documented for the coastal populations adjacent to Tillamook Bay, a similar relationship likely exists. It was found in Washington that mating and spawning take place in coastal waters. Mating takes place primarily in March and April but may extend as late as July. After mating, the spermatophores remain viable in the female for many months and fertilize the eggs upon extrusion (Wild 1983). Each female carries as many as 1.5 million eggs. The eggs hatch in the spring into larvae which remain pelagic for four to five months. The larvae undergo a series of molts and transformations and by May or June are abundant in coastal and estuarine waters as megalops. After the last molt of the megalops stage, the young crabs settle to the bottom in both coastal and estuarine environments. Crab that initially settle in estuaries grow substantially faster than those that settle along the open coast. Juveniles remain in the areas of settlement over their first winter and then most coastal one-plus year old crabs immigrate to estuaries to join siblings that settled there the previous year. By September of the second year, many crab at about 4 inches (10 cm) carapace width emigrate to the open coast where they reach maturity. Another study conducted in Grays Harbor (Stevens and Armstrong 1984) found that there is a secondary emigration to coastal waters when crabs that remain in the estuary reach sexual maturity. Thus it appears that estuaries play a critical role in the maintenance of crab populations along the Washington coast and probably along the Oregon coast as well.

Estuarine habitats utilized by Dungeness crab vary considerably by crab age. Early juvenile crabs have been shown to prefer eelgrass beds and intertidal substrate with a high content of clam or oyster shell (Stevens and Armstrong 1984, Eggleston and Armstrong 1995). McMillan *et al.* (1995) found that post-settlement mortality of crabs in northern Puget Sound correlated inversely with habitat complexity. Survival was highest in a mixed sand and gravel substrate with an overstory of attached drift algae, intermediate in eelgrass, and lowest on open sand. These studies suggest that eelgrass beds and areas with complex substrate conditions such as are found in oyster beds and the shell-dominated substrates in lower Tillamook Bay may be very important as refuge habitat for early juvenile crabs.

As juvenile Dungeness crab grow larger, they move from eelgrass beds and other protective shallow water habitat into deeper water and prefer the lower half of the estuary where salinity is generally higher. A study comparing densities of crab in subtidal and intertidal habitats (Stevens *et al.* 1984) suggests that adult crabs may be sensitive to high light levels and are generally found during the day in relatively deep water where light intensity is low. Movements of crab from subtidal areas to intertidal areas during darkness have been recorded. These movements appear to be related to greater food availability on the intertidal flats (Stevens *et al.* 1984). Deep subtidal habitat is recovering in the Bay from the sedimentation due to the Bayocean Spit breach, the Tillamook Burn, and the subsequent salvage logging (see Bathymetry discussion).

The invasive, exotic Green Crab (*Carcinus maenas*) is in the early stages of colonizing the Bay. The crabs may have washed in on ocean currents as megalops (young developmental stage) since all of the crabs found to date are of approximately the same size In Tillamook Bay and in other local bays (Faudskar, J. personal communication 1998).

Status of Mammal Species

Harbor seal populations had declined drastically in Oregon by the time the Marine Mammals Protection Act went into effect in 1972 (Table 8-3). Many estuarine haul-out areas had been abandoned due to harassment and killing of the seals by fisherpersons and bounty hunters hired by the state (Brown and Mate 1983). Oregon began a statewide census of marine mammals in 1977 using aerial surveys of haul-out areas and multiplying the observed numbers by a correction factor to account for seals that were not hauled-out at the time of the flyover. The correction factor was determined from radio-tagging studies. The statewide aerial count of harbor seals went from 2224 adults and juveniles in 1972 to 5322 in 1996. This results in a population estimate for 1996 of just under 10,000 adults and juveniles (Brown 1997). The annual growth rate for the population was estimated at 5% per year for the period 1982–1992, and 0.3% per year for the period 1988–1996 (Brown 1997). The radio tagging studies also indicated that there is interchange between different estuaries such as Netarts and Tillamook and that this may be due to good quality haul-out areas in Tillamook for giving birth, or opportunistic feeding in Netarts.

Table 8-3. Recent increases in Pacific Northwest marine mammal populations

Species/Location	Past Date	Abundance	Recent Date	Abundance
Harbor seals				
British Columbia	1970	9,000–10,500	1988	75,000–88,000
Washington	1972	2,000	1992	38,000
Oregon	1984	4,000–5,000	1992	9,500–12,200
Tillamook Bay	1973	250	1993	600
California sea lion				
United States	1978	36,000	1988	67,000

Sources: Palmisano, J., R. Ellis and V. Kaczynski. 1993. The impact of environmental and management factors on Washington's wild anadromous salmon and trout. Rept. prepared for: Washington Forest Protection Association and the State of Wash. Dept. of Natural Resources, Olympia, WA. 369 pp.

Kaiser, R., R. Lowe and R. Brown. 1995. Tillamook Bay coho stock status report. Section 7, Nonhuman predation on salmonid stocks. Tillamook Bay Coho Task Force, Oregon Dept. of Fish and Wildlife.

Estuary Habitat

The first comprehensive inventory of the habitat types (see Figure 8-1) around the Tillamook Estuary was performed by ODFW in 1979 and is contained in the Oregon Estuary Plan Book (Department of Land Conservation and Development [DLCD] 1987). The classification system used by ODFW was based on the Cowardin classification system used by United States Fish and Wildlife Service (USFWS). The habitat types are grouped under the following categories: unconsolidated bottom, aquatic bed, shore, flat, and tidal marsh; these groups are further subdivided into intertidal and subtidal. The list of habitat types and their 1979 acreages are contained in Table 8-4.

The only other complete classification of the estuarine habitat types is contained in the GIS classified image (EELGRASS) produced on contract for the TBNEP by Earth Design consultants (Strittholt and Frost 1996). The contractor classified aerial photographic images flown in 1995 at low elevations. The habitat types classified on the images are: terrestrial plants (salt marsh), green algae, dense mixed algae, dense eelgrass, sparse eelgrass, sparse mixed algae on rocky substrate, sparse mixed algae on smooth substrate, sand/gravel/shell, mixed sand and silt, mud/organic debris, developed, and water. This classification system does not match that used by ODFW previously making it difficult to do a direct quantitative comparison between the two points in time.

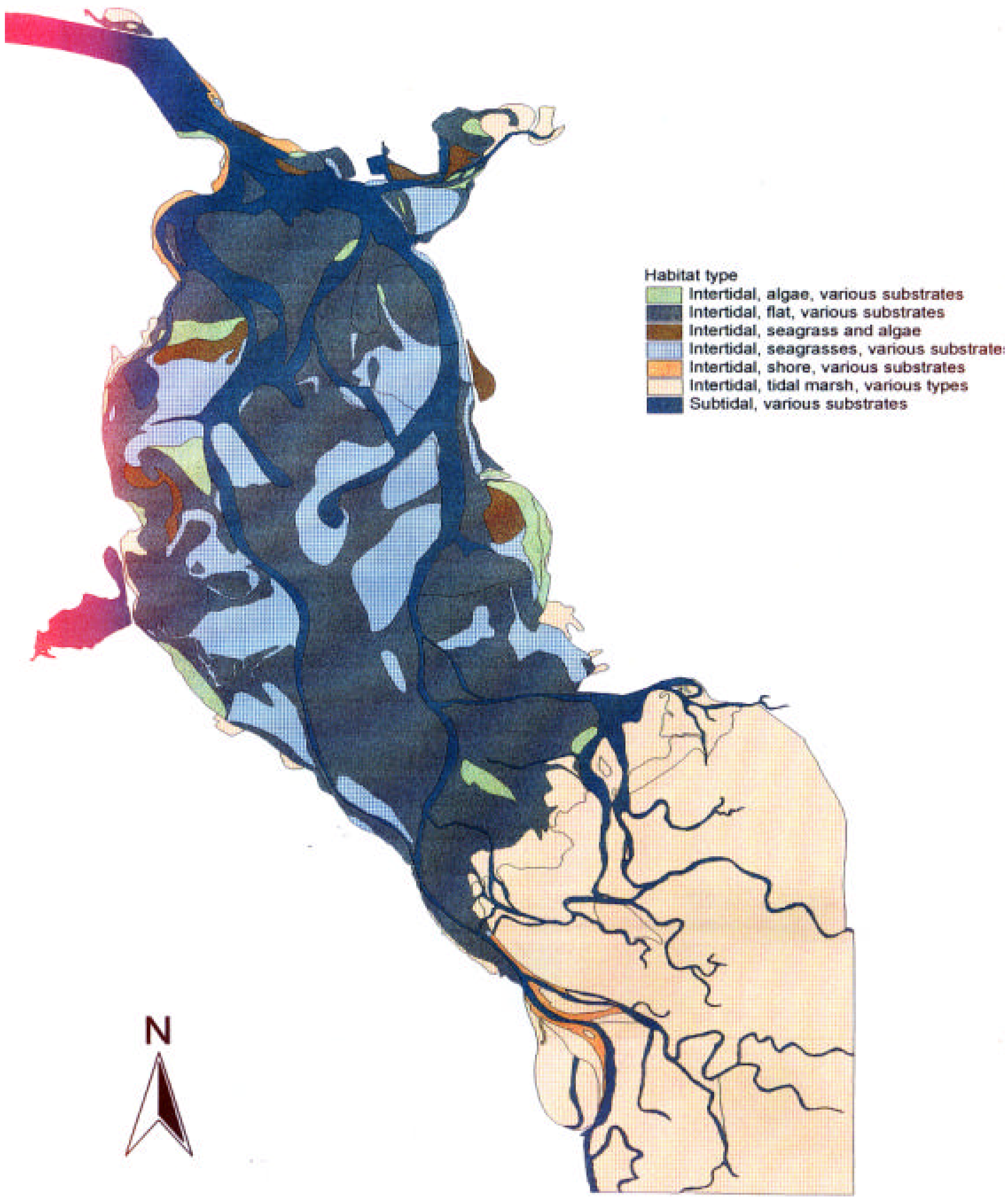

Figure 8-1. 1972 Tillamook Bay habitat classifications from the Oregon Estuary Plan Book
(Source: Department of Land Conservation and Development. 1987. The Oregon Estuary Plan Book. 126 pp., TBNEP GIS layer ESTUHABS)

Table 8-4. Summary of the two habitat inventories conducted in 1979 and 1995 for Tillamook Bay

Cowardin Numeric Code[7]	1979 ODFW Classification	1979 Acreage	1995 Habitat Classes
Unconsolidated Bottom			Sand/Gravel/Shell
1.1	Unspecified type	811.6	
1.1.1	Sand	540.5	
1.1.2	Sand/mud	698.8	Mixed Sand and Silt
1.1.4	Shell	7.1	
1.1.6	Cobble/gravel	24.3	
Aquatic Bed			
1.3.9(2)	Seagrass on sand/mud	40.8	
2.3.9	Seagrass	282.7	Dense Eelgrass/Sparse Eelgrass
2.3.9(2)	Seagrass on sand/mud	884.9	
2.3.9(3)	Seagrass on mud	317.6	
2.3.9/10	Seagrass/algae	169.4	
2.3.9/10(3)	Seagrass/algae on mud	15.5	
2.3.9/10(6)	Seagrass/algae on cobble/gravel	13.4	
2.3.10	Algae	46.1	Green Algae/Dense Mixed Algae
2.3.10(1)	Algae on sand	37.6	Sparse Mixed Algae on Smooth Substrate
2.3.10(2)	Algae on sand/mud	93.0	“ ”
2.3.10(3)	Algae on mud	93.1	“ ”
2.3.10(6)	Algae on cobble/gravel	29.2	Sparse Mixed Algae on Rocky Substrate
Tidal Marsh			Terrestrial Plants
2.5.11	Low salt marsh	322.7	
2.5.12	High salt marsh	558.4	
2.5.14	Shrub marsh	3.3	
Shore			
2.1	Unspecified type	59.7	
2.1.1	Sand	32.8	
2.1.6	Cobble/gravel	20.5	
2.1.8	Bedrock	0.2	
Flat			
2.2	Unspecified type	149.1	
2.2.1	Sand flat	449.7	
2.2.2	Sand/mud	2991.2	
2.2.3	Mud	501.4	Mud/Organic Debris
2.2.5	Wood debris/organic	1.0	“ ”
2.2.6	Cobble/gravel	20.7	
			Developed

[7]Cowardin codes beginning with 1 are intertidal and with 2 are subtidal.

Sources: 1979 ODFW Classification. Department of Land Conservation and Development (DLCD). 1987. The Oregon Estuary Plan Book, 126 pp.

1995 Habitat Classes. Earth Designs Consultants. 1996. Eelgrass mapping of Tillamook Bay Oregon (GIS layer). TBNEP

Estuary Bathymetry

Three bathymetric surveys of Tillamook Bay have been performed; they were in the years 1867, 1957, and 1995. The surveys quantify the changes in bay bathymetry due to sedimentation, human activities such as dredging, and tidal flushing over the periods covered by the surveys. The Bay has received large contributions of sediment during this period. The sediment sources include:

- the breach of Bayocean Spit between 1952 and 1956;
- deforestation in the watershed;
- the Tillamook Burns of 1933, 1939, 1945, and 1951 and subsequent salvage logging; and
- land use practices in the watershed including road construction, agriculture and urbanization.

In addition, the bay has been altered by wetland conversion through diking and draining, the construction of pile dikes to direct flows in the bay, jetties constructed at the mouth, and dredging of navigation channels (Bernert and Sullivan 1997). Channelization of the rivers and diking of the wetlands has contributed to conducting sediment to the Bay that was formerly deposited on the floodplain.

The 1867 bathymetry (Figure 8-2) shows a complex structure with three well defined, deep channels that interconnected and branched in response to the tides and freshwater inflows from the rivers. There was a broad range of habitats scattered throughout the bay ranging from deep holes (greater than 20 feet deep), to low islands composed of LWD. The large holes immediately adjacent to the low islands may have been created by the interaction of currents with the abundant large woody debris present in the Bay at that time (Bernert and Sullivan 1997).

The 1957 bathymetry (Figure 8-3) shows a much simplified structure with only two main channels with far less channel branching and interconnectedness. Pile dikes were constructed by the COE in the late 1800s to focus tidal and freshwater flows into two main channels. The concentrated flows scoured the channels and reduced the need for dredging, but the dikes also contributed to reduced channel complexity and extensive shoaling in the southwest portion of the Bay. Much of the structural diversity has been lost due to sedimentation and the removal of virtually all large woody debris. The sedimentation was due primarily to the Tillamook Burn and salvage logging, and the Spit breach. The removal of woody debris was intended to increase navigability for shipping, fishing, and to reduce obstacles to the movement of log rafts in the bay. A comparison of the 1957 bathymetry relative to 1867 shows that: the range of depths is greatly reduced; the area of the Bay is reduced; and the total volume of the Bay (and thus the tidal prism) is greatly reduced. In short, the Bay and its habitat values were heavily impacted by sedimentation and LWD removal during the 1867 to 1957 period.

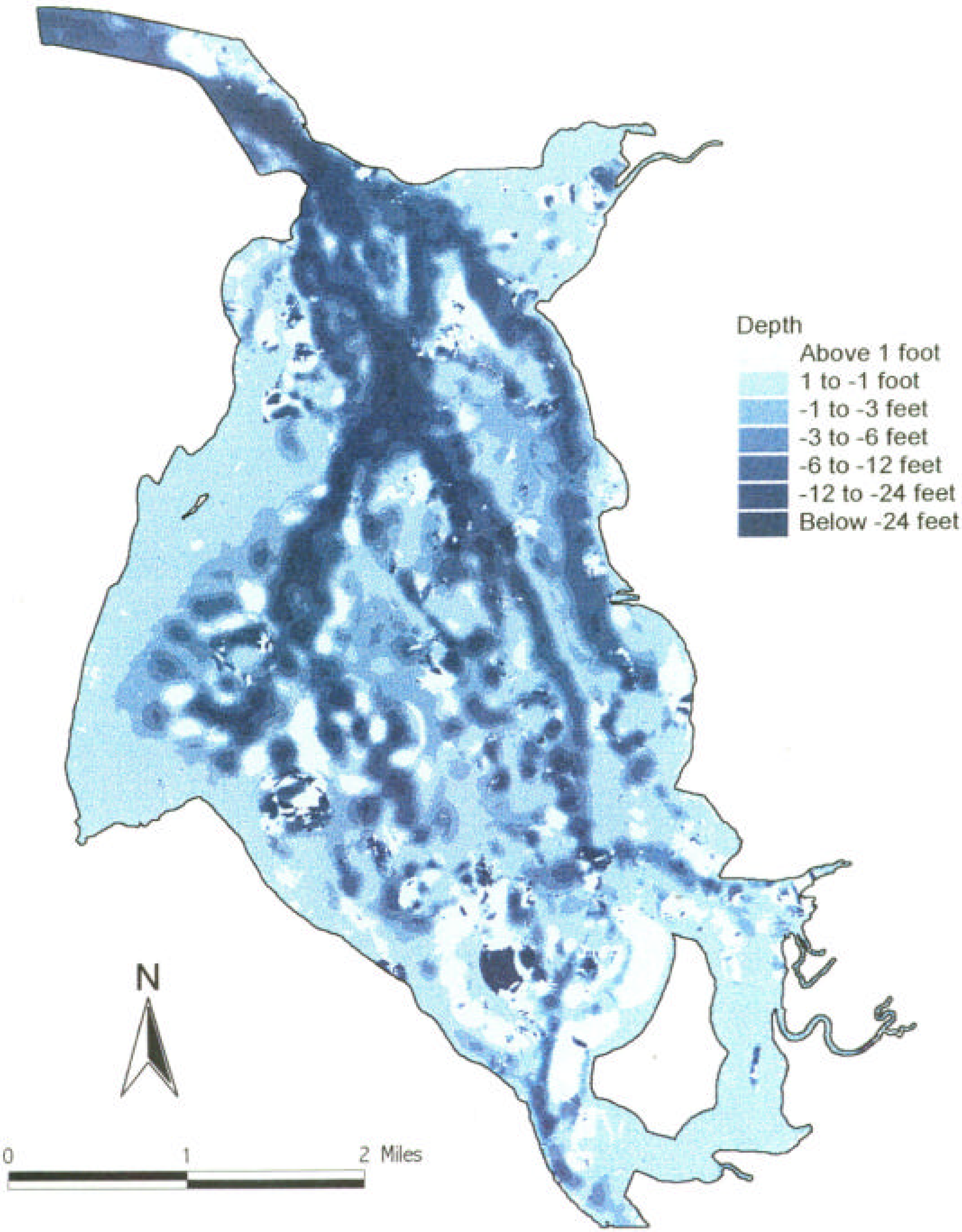

Figure 8-2. Tillamook Bay bathymetry in 1867. (Source: TBNEP GIS layer TIL567P)

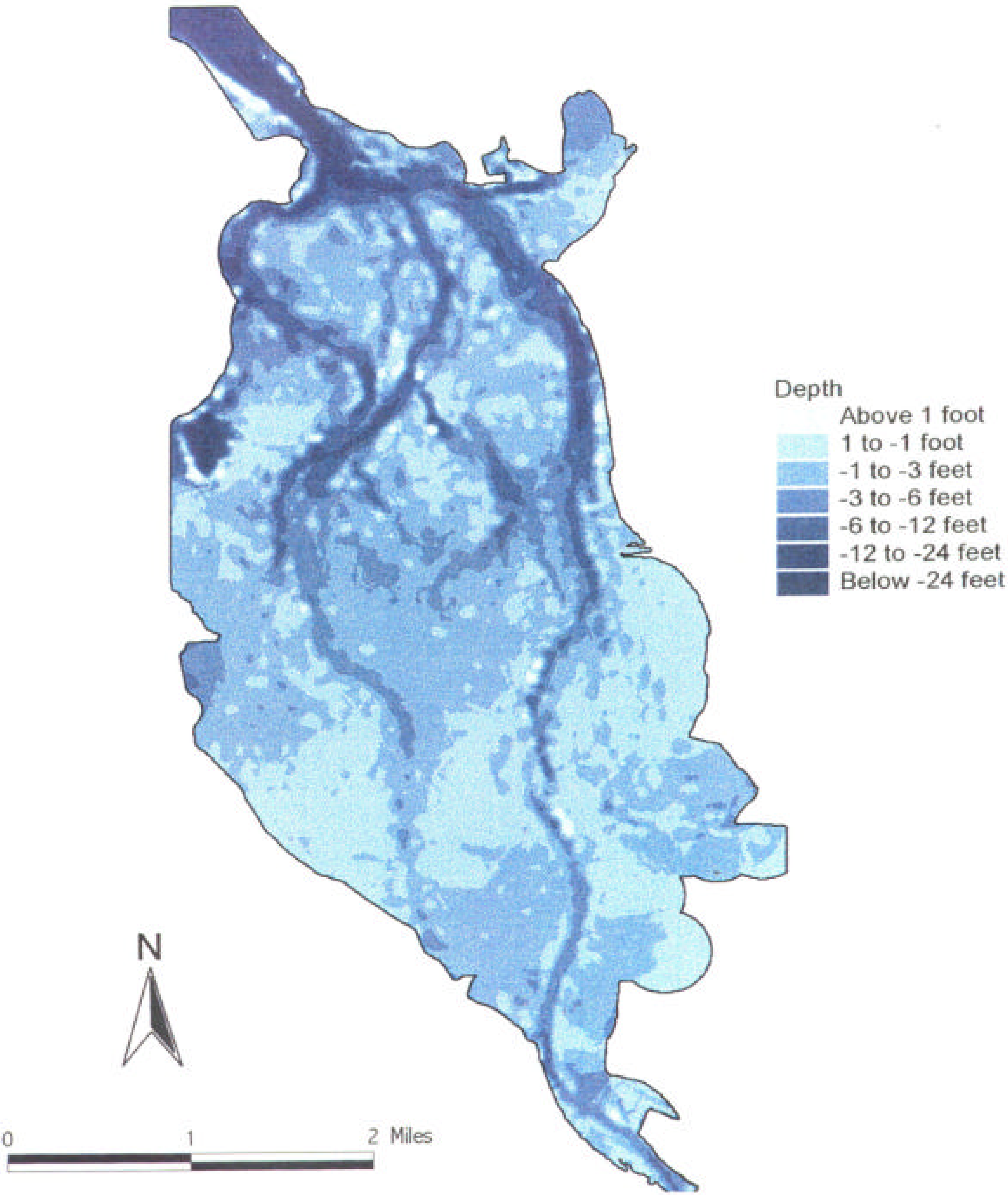

Figure 8-3. Tillamook Bay bathymetry in 1957. (Source: TBNEP GIS layer TIL557P)

The 1995 bathymetry (Figure 8-4) shows a recovering, but still simplified, bay structure. The channels are deeper and more clearly defined relative to the 1957 bathymetry. The channel system is redeveloping branching and interconnectedness as well. Many of the shoals in the middle of the Bay between the main channels appear to be deeper than in 1957, suggesting that some of the sediments accumulated in the preceding period from the Spit breach and the Tillamook Burn/salvage logging have been flushed out or redistributed by tidal action and freshwater flows. On the other hand, some areas around the southwest and southeast shores of the bay have filled in and tidal marshes have formed. Overall, the area of the Bay declined due to tidal marsh formation and the volume increased slightly due to deepening, widening and extension of the channel system.

The following discussion summarizes the changes between 1867 and 1995 and is depicted graphically in Figure 8-5. Bay structure is less complex due to: removal of large woody debris; alteration of channels by pile dikes; sediment filling of deep holes; and shoaling around the margins of the Bay. The area of the Bay is reduced due to: diking (Bayocean Spit); filling (Garibaldi); road construction (Highway 101 through Larson Cove and Cape Meares Road along the southwest shore); and saltmarsh accretion (river delta region and the southwest shore). The Bay volume is reduced due to sedimentation and the preceding factors.

The Status of Eelgrass

Past and Current Distribution and Area of Eelgrass Beds

The earliest map of eelgrass beds in Tillamook Bay was produced in 1971 as part of an inventory of the freshwater and marine resources conducted by the Oregon Fish Commission. The 1971 inventory included maps of other resources such as herring spawning areas, clam beds, and oyster lease areas. The second map of eelgrass distribution was published in 1975 as part of 1974–1975 fish surveys (Forsberg *et al.* 1975). Both of these maps showed the general distribution of eelgrass but did not provide estimates of density. A partial map of eelgrass beds was prepared and mapped on the transects sampled for clams in 1974–76 (Gaumer 1977). This map provided only partial coverage of the estuary, but did distinguish between sparse, moderate, and dense eelgrass beds. A comprehensive map of the benthic habitats was prepared by ODFW in 1979 and contains the most complete early map of the eelgrass beds in the estuary (Department of Land Conservation and Development 1987).

Due to the uncertain accuracy of the early mapping efforts prior to the 1979 habitat map, quantitative assessment of changes in the real extent of eelgrass beds is not warranted using those maps. However, some qualitative observations regarding changes in distribution can be made. In comparing the maps developed in the 1970s, it is apparent that in the early- to mid-1970s most eelgrass beds were located in the following areas: (1) the middle section of the Bay, (2) along the northeastern edge of the Bay, and (3) on the Miami River delta near Garibaldi. In 1979, the distribution and area of eelgrass was similar in the middle and northeast sections of the Bay to the earlier maps. New beds had appeared in the southern portion of the Bay on shoals around the mouth of the Kilchis River and northwest of the mouth of the Tillamook River.

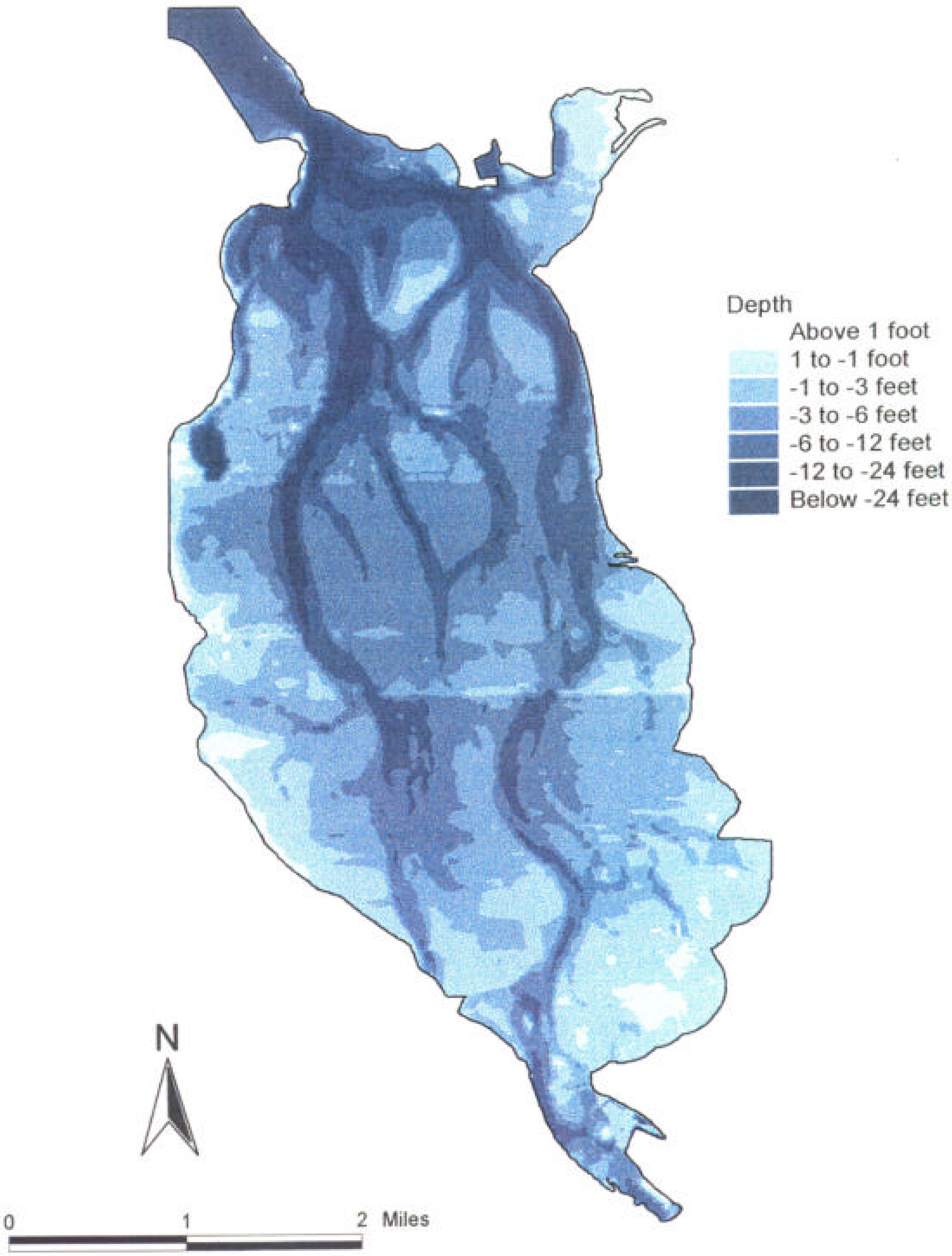

Figure 8-4. Tillamook Bay Bathymetry in 1995. (Source: TBNEP GIS layer TIL595P)

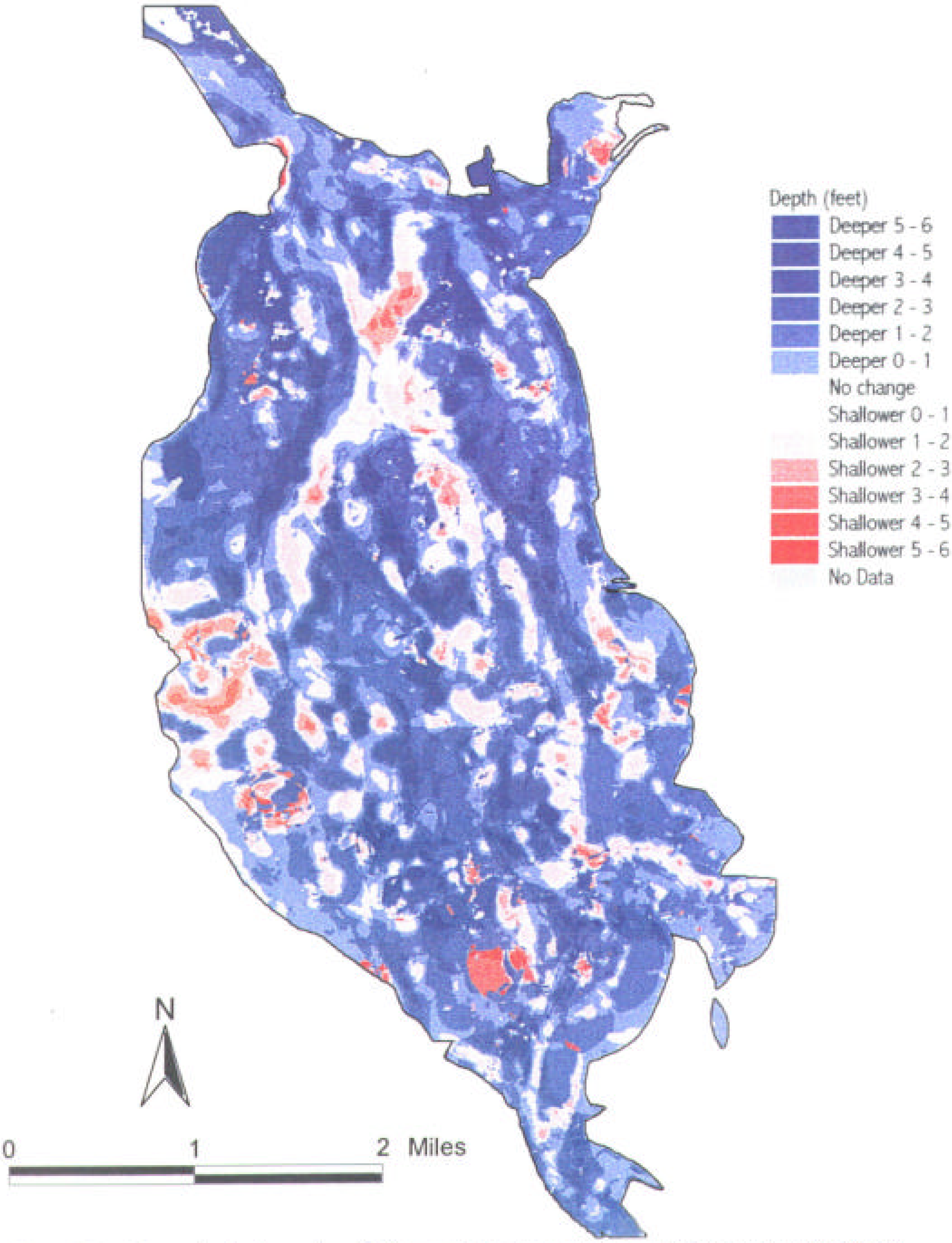

Figure 8-5. Change in bathymetry of Tillamook Bay from 1867 to 1995. (Source: TBNEP GIS layer CH67_95P)

In July 1995, the TBNEP contracted to acquire multispectral airborne video of Tillamook Bay during the lowest tide of the month. The major emphasis of this work was to map eelgrass distributions while getting a more detailed picture of the Bay's various substrates. Figure 8-6 shows the classified imagery, which was field verified. Dense and sparse eelgrass beds could be distinguished, but some eelgrass may also occur in areas designated as mixed algae because separation of species in these areas was not possible.

Changes in Eelgrass Distribution and Area between 1979 and 1995

The 1995 map contains one new, large eelgrass bed east of the "Deep Hole" by Bayocean Spit. The majority of the large eelgrass beds in oyster plats (middle section of the Bay) found on the 1979 map are not found on the 1995 map. The remaining beds in the middle section of the Bay on the 1995 map are small, sparse, and scattered. Eelgrass was still present on the Miami River delta and along the edges of the main channels at the northern end of the Bay. Substantial expanses of dense eelgrass are present on portions of several tidal flats at the northern and southern ends of the Bay. The beds at the southern end of the Bay were not identified on the mid-1970s maps. During field checking of the 1995 map, field personnel determined that the majority of the new eelgrass beds south of Bay City were composed of the annual *Zostera japonica*, while the central and northern beds were composed of the perennial *Zostera marina* as they were in the 1970s.

The ODFW 1979 habitat map was compared quantitatively to the 1995 imagery map. The area of pure eelgrass in 1979 was 1485.2 acres, and the area of mixed eelgrass/algae was 198.3 acres for a total of approximately 16% of the Bay area. The 1979 map did not have different density classes for eelgrass. The 1995 eelgrass map shows approximately 11% of the Bay area as occupied by dense or sparse eelgrass beds of both species (Strittholt and Frost 1996). The 1995 map did not have a class for mixed eelgrass/algae.

These comparisons indicate that: 1) eelgrass bed distribution in Tillamook Bay declined approximately 31% during the past 20 years, particularly in the middle portion of the bay; and 2) the presence of large beds of *Zostera japonica* in the southern portions of the Bay is another major change in the distribution and species composition of eelgrass in the Bay.

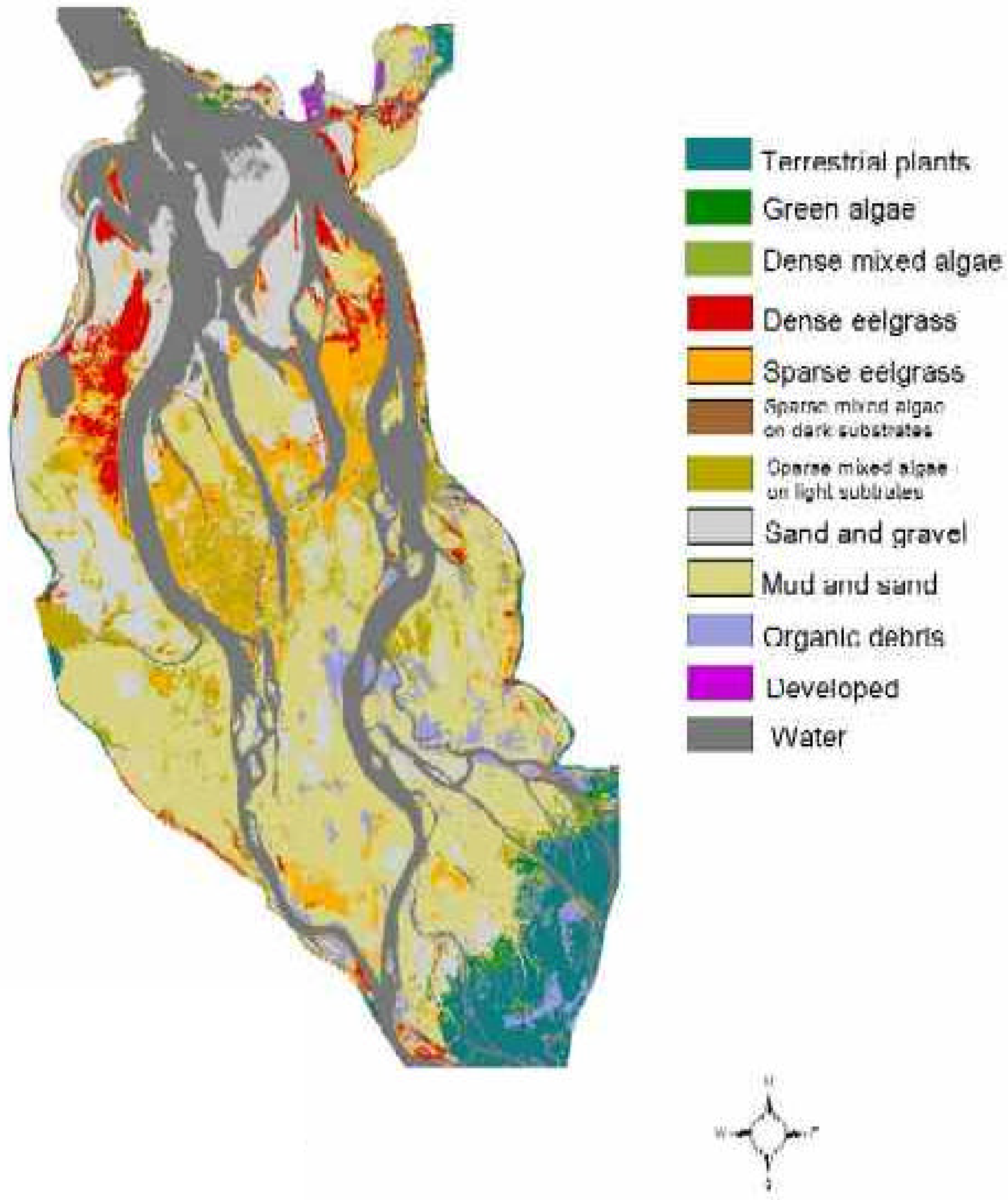

Figure 8-6. Tillamook Bay Substrate Composition in 1994 from a Satellite Image Classification (Source: TBNEP GIS layer EELGRASS)

Interactions With Other Benthic Species

Oysters are often grown in association with eelgrass beds because eelgrass beds are typically located on relatively firm, stable substrate. The few studies that have investigated the effect of oyster culture on eelgrass beds indicate that the presence of an active oyster site results in decreased eelgrass abundance (Rumrill and Christy 1996, Pregnall 1993, Waddell 1964, Everett *et al.* 1995). These studies have documented decreased shoot density and percent cover, as well as poor natural recovery after oyster culture ceases in a given area. However, most of these studies concern rack or stake culture, which may have very different mechanisms and effects than ground culture. The only study to investigate the impact of ground culture on eelgrass also found that ground culture causes a decrease in eelgrass abundance (Rumrill and Christy 1996). There is some evidence that the presence of oysters in eelgrass beds can be beneficial. Oysters remove food particles from the water column and deposit the undigested component as feces on the substrate. The fecal material may provide additional plant nutrients for eelgrass growth (Langdon, C. pers. com. 1997). No carefully designed research to evaluate this effect has been conducted in Pacific Northwest estuaries (see planned study under shrimp below).

There is some indication that there is a negative interaction between burrowing shrimp and eelgrass. Burrowing shrimp move large quantities of sand in their burrowing activities, which can bury the eelgrass turions in extreme cases. The burrowing also loosens the substrate and the lower density is not as favorable for eelgrass. The primary shrimp species in eelgrass beds is the mud shrimp (*Upogebia pugettensis*) since it is primarily confined to the middle zone of the bay on substrates with substantial fines (Golden *et al.* 1997). No definitive study has been completed on the interaction between burrowing shrimp and eelgrass has been completed for the Bay, but a study is currently being implemented to study oyster culture, eelgrass, and burrowing shrimp interactions.

Human Physical Alterations of the Estuary

Engineered modifications to the estuary by Euro-American settlers began in the late 1800s and continue to the present day. The modifications take several forms including: dredging of channels and river mouths to improve navigation and reduce flooding; diking and draining of tidal wetlands for conversion to agriculture; construction of estuary pile dikes to direct water flows in the estuary; construction of jetties to improve access to the Bay entrance; filling of portions of the Bay for conversion to other uses; and removing LWD from river mouths to improve navigation and reduce flooding. These modifications will be discussed in the following sections.

Dredging

The dredge equipment and its use, and spoil disposal method are: pipeline dredge for the inner channel and boat basins with land disposal; hopper dredge for the outer channel with ocean disposal; clamshell dredge for the inner channel with ocean disposal; barge dredge for inner channels with ocean disposal; and agitation dredge for the inner channel with tidal flushing of the spoils.

Between 1929 and 1979 approximately 1.6 million yd^3 of sediment were dredged from the entrance bar and entrance channel. These dredge spoils were deposited 3 miles offshore in the ocean, which is required of dredged material for navigational purposes. Since 1979, only 71,000 yd^3 have been dredged from the bar and inner channel; all of these spoils were disposed of on land. Dredging to alleviate flooding and other emergency purposes has had less regulation and resulted in the disposal of dredge spoils onshore. Dredge spoils have been deposited onshore at the commercial area at Garibaldi (land owned by the Port of Bay City), on the alluvial fan near the mouths of the Wilson and Trask Rivers, on Bayocean Spit at Kincheloe Point and the breach site, and lesser amounts at various other areas along the bay margin. Sites considered by the COE for future onshore disposal are the existing Garibaldi commercial site and a diked area at the upper end of Miami Cove (COE 1975).

Initial dredging activities begun in the 1890s were intended to improve navigation to the southern half of the bay between Bay City and the town of Tillamook. The dredging was done in connection with the construction of pile dikes, and its effects will be discussed under the section on pile dikes.

Regular dredging of the primary navigation channel between Bay City and Tillamook was abandoned by 1925 due to the cost of the frequent dredging required to keep the channel open. The usual return period for dredging of this type is three years, but following one dredging the channel refilled with sediment in only three months. The focus was then switched to the Miami Cove port and boat basin, which was constructed in 1927. An 18 foot deep, 200 foot wide channel across the bay mouth to Miami Cove, and a 500 foot square turning basin were authorized and constructed at that time. The Garibaldi boat basin and channel was authorized in 1958 and 160,000 yd^3 were dredged for the construction of the boat basin and deposited onshore at Garibaldi. Since that time, all dredging has been done on the Bay entrance bar, the inner channel to Garibaldi and in the Miami Cove boat basin. From 1961 to 1975, this maintenance dredging totaled 296,000 yd^3, with all but 32,000 yd^3 deposited at sea. The entrance bar continually accumulates littoral sands through wave action and must be periodically dredged to ensure the safety of passing boats. The last major dredging effort was undertaken in 1976 and was designed to keep the entrance bar and channel open for an extended period.

Another use of dredging has been for flood relief. Following flooding in the winter of 1971–72, the mouths of the Wilson and Trask Rivers were dredged to increase channel capacity to former levels. An estimated 108,000 yd^3 were removed and deposited on the adjacent alluvial fan. Further dredging of this type has been suspended because tidal surges associated with storms negate any benefit provided by increased channel capacity (COE 1975).

Diking and Draining

The delta regions of the bay surrounding the mouths of the five rivers formerly supported large acreages of undisturbed tidal marsh and floodplain grasslands. Euro-American settlers recognized that these lands would make highly productive pasture lands. The process of diking and draining these lands for conversion to agricultural uses began fairly early in the Euro-American settlement process. Some river and delta islands were diked along their entire shores, but for many riverfront areas it was sufficient to only build a dike along the river edge and install tide gates. Ditches with and without tile drains were then constructed in the marshes to collect subsurface and surface water and convey it to tide gates in the dikes. Tide gates allow overland flows to enter the rivers or bay at low tide while stopping the return entry of tidal waters at high tide. Eventually, the majority of the marshland in the tidal zone was diked and drained. Additional tidal areas farther back from the Bay were also ditched to lower the water table and allow them to be converted to agricultural uses. For further discussion see the Loss of Wetlands discussion.

Pile Dikes

Beginning in 1893 and ending in 1897, the construction of pile dikes was combined with dredging to increase the navigability of channels in the southern portion of the estuary. The dikes were located around the mouth of the Wilson River (2), off Dick Point (1), in the center of the bay west of Kilchis Point (2), and around Kilchis Point (2). The dikes focused the flows of river water and tides in the channels to increase flushing thus helping to keep them clear of sediment. The channels were dredged simultaneous to the construction of the dikes and then the concentrated flows were expected to keep them open. The typical dike consisted of two parallel rows of pilings with rock fill in between.

A side effect of the construction of the dikes was increased sedimentation in the southwestern portion of the Bay leading to extensive shoaling. Eventually, the combination of pile dikes and dredging resulted in the reduction of the four original channels in the bay to only two channels. Remnants of some of the pile dikes are still visible in southern portions of the Bay.

Construction of Jetties

Due to the treacherous nature of the entrance bar, considered by some to have been the most dangerous in Oregon, the COE was authorized in 1912 to construct two jetties at the entrance to the bay. The north jetty, constructed between 1914 and 1918, was initially 5400 feet long. Due to limited funds, only the north jetty was constructed at that time. Since that time, the north jetty was repaired and extended to 6000 feet in 1933, and subsequently rehabilitated on two other occasions. The 6000 foot long south jetty was constructed between 1969 and 1974. Both jetties are of the rubblemound type and were constructed from stone originating from both local quarries and at least one quarry on the Columbia River. A total of 963,211 tons of stone have been used in the construction and maintenance of the north jetty. Approximately 1,436,000 tons were used in the construction of the south jetty, with an additional 180,000 tons projected for use in maintenance during the first 35 years following construction.

Serious erosion of the Bayocean Spit was correlated with the construction of the north jetty and many local residents feel that the north jetty caused erosion and the breaching of the spit in 1952.

The north jetty definitely caused the accretion of significant dune acreage on its north side at Barview, and these dunes are now covered with a stable pine/beach grass community. Since the construction of the south jetty, significant dune accretion has occurred on the west side of Kincheloe Point. The Bayocean Spit appears to be stabilized based on the recent dune accretion and the COE dike construction to close the breach.

Construction of Fill Areas

Between 1867 and 1977 approximately 102 acres (or 2.5%) of the bay tidelands were filled and converted to other uses (COE 1975). The largest single fill was the filling of the breach in the Bayocean Spit and construction of the dike to protect that fill. The spit breached in 1952, allowing direct access for storm driven waves and sediment to enter the central bay. The COE constructed a 1.4 mile long sand filled dike to close the breach, hydraulically pumped sand taken from the bay to fill the area behind the dike, and then established non-native European beach grass (*Amophila arenaria*)and Scotch broom (*Cytisus scoparius*) erosion control plantings on the area.

Other fills during this period consisted of: 200,000 ft^2 added to Kincheloe Point by the COE during the construction of the south jetty; 500,000 ft^2 in Garibaldi for construction of commercial areas; and fills totaling 1.5 million ft^2 in the deltas of the five rivers (COE 1975). The majority of the fills not conducted by the COE were constructed before the current regulatory permit process was put in place and thus were unregulated. Since 1977, filling of the bay has been largely curtailed by county plans and coastal zone management plans.

Removal of Large Woody Debris

The COE began removing LWD from the rivers and estuary in the late 1800s to increase navigability and reduce flooding. A total of approximately 9200 snags were recorded as being removed under COE contract in the period from 1889–1919. This number is low because not all trees were recorded and these numbers do not include snags removed by private parties, which were quite numerous in some places. Currently, much of the LWD reaching the estuary appears to be removed for use as firewood.

LWD performs important ecological functions in river deltas and estuaries. These functions include: connecting the rivers to the floodplain by promoting flooding; providing habitat for juvenile and adult fish; providing a source of food for invertebrates; providing perches for birds; providing nurse logs for Sitka spruce and shrubs to germinate and grow on; and stabilizing shoreline in the tidal marshes and dune areas. Historically, there were log jams in the mouths and lower portions of the rivers as well as numerous logs in the tidal marshes, dunes, and estuary proper (Coulton *et al.* 1996). The ecological functions performed by LWD have been severely diminished in the estuarine system resulting in the alteration of numerous ecological processes. These processes include the retention of sediment on the floodplain, the movement of energy and material through the food web, the accretion and stabilization of tidal marsh and dune areas on the spit, migration of salmonids into and out of the bay, and colonization of tidal marsh areas by Sitka spruce and shrubs.

9.0 FISH AND WILDLIFE

Introduction

The five watersheds of the Tillamook Basin formerly produced large numbers of the five salmonid species. Only one of the five salmonid populations is now considered healthy (Klumph and Braun 1996). Anecdotal reports claim that several species of fish have disappeared from the estuary in the last 50 years. The forested upland and coastal terrace habitats have been greatly altered by human activities such as forestry and timber harvesting, agriculture, and development with resulting impacts to fish and wildlife species.

This section covers:

- salmonid populations,
- salmonid critical habitat areas,
- habitat needed for salmonid life stages,
- channel modifications affecting habitat,
- features blocking fish passage,
- critical lowland areas needing restoration,
- unscreened water diversions,
- endangered plant and animal species; and
- wildlife species residing in the watershed.

Salmonid Populations[8]

Anadromous salmonid species known to occur in the Tillamook Bay Watershed include chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), and sea-run cutthroat trout (*O. clarki*).

[8] **Sections on salmonid populations largely taken from: Biological Resources, Chapter 3 in TBNEP. 1998. Tillamook Bay Environmental Characterization: A Scientific and Technical Summary.**

Population Status and Trends

The most useful kinds of information for assessing the present status and trends of anadromous salmonid populations include the following:

- numbers of adults returning to spawn (escapement);
- numbers of fish harvested;
- distribution and abundance of juvenile fish within the freshwater and estuarine environments;
- smolt production (chinook, coho, steelhead, cutthroat trout); and
- the influence of hatchery fish on the naturally spawning populations.

Table 9-1 summarizes findings on the general health and trends in abundance of the Tillamook Bay anadromous salmonid species and races. Health was considered poor if the naturally spawning population appeared to be heavily supported by hatchery fish and/or if the population is severely depressed compared with historic conditions. Of the five species present in the Watershed, only fall chinook salmon appear to be healthy and relatively abundant. The rationale for the conclusions shown in Table 9-1 is described in the following species-by-species summary of available information relating to status and trends for the Tillamook Bay salmonids.

Chinook salmon

Fall chinook habitat includes the mainstem, the North and South Forks, Little South Fork, the lower portion of Sam Downs Creek, and the lower portion of Clear Creek. The mainstem of the Kilchis from the estuary to the confluence of the North and South Forks has been identified as spring chinook habitat.

Mature fall chinook (2 to 6 years of age) return to all five of the major subbasins from early September through mid-February. Peak entry into the rivers occurs in mid-October. Fall chinook spawn from October to mid-March (Nicholas and Hankin 1988).

Spring chinook salmon are believed to have a small population in the Kilchis River relative to the Wilson and Trask based on catch data (Klumph and Braun 1996). Spring chinook enter bay tributaries from April through June. River entrance probably peaks in May (Nicholas and Hankin 1988). Spawning begins as early as the first week in September and peaks during the last week of September or first week of October.

Table 9-1. Status and recent population trends of Tillamook Bay anadromous salmonids

SPECIES/RACE	STATUS	RECENT POPULATION TRENDS
Chinook salmon		
fall	**healthy**	**stable or increasing**
spring	**heavily supported by hatchery fish, depressed compared with historic abundance**	**possibly declining**
Coho salmon	**heavily influenced by hatchery fish, severely depressed compared with historic abundance**	**declining**
Chum salmon	**depressed compared with historic abundance**	**declining**
Winter Steelhead	**heavily influenced by hatchery fish, numbers appear low**	**declining**
Sea-run cutthroat trout	**depressed**	**possibly declining**

Source: Based on data in Nicholas, J., and D. Hankin. 1988. Chinook salmon populations in Oregon coastal river basins: Description of the life histories and assessment of recent trends in run strengths. Oregon Department of Fish and Wildlife info. rep. no. 88-1. 359 pp.

Chinook salmon were fished commercially by gillnetting in Tillamook Bay from about 1893 until 1961 when the fishery was permanently closed. As many as 28,000 chinook salmon (both races) were packed annually on Tillamook Bay from 1893 through 1919, although the pack was very erratic and was frequently less than 5,000 fish or not reported. From 1923 through 1946, commercial landings remained relatively stable ranging from 12,000 to 31,000 fish and averaged about 17,000 fish (Nicholas and Hankin 1988). The commercial catch declined from 1947 through 1961. The decline may have been related, at least in part, to increased regulatory restrictions on the fishery.

The recreational catch of fall and spring chinook salmon has been estimated since 1969 from annual returns of salmon/steelhead punch cards (Nicholas and Hankin 1988, Nickelson *et al.* 1992, ODFW 1995b, Kostow 1996). These catch estimates indicate a generally increasing trend from 1969 through 1993 (period of available data) for fall chinook salmon. The recreational catch of fall chinook averaged about 15,900 fish between 1985 and 1993. When compared with the average annual commercial catch of about 17,000 for the period 1923–1946, the present level of harvest appears remarkably strong and stable. Although hatchery fish contribute to the fall runs, it is believed that most fall chinook are produced from naturally spawning fish (Nicholas and Hankin 1988).

The recreational catch of spring chinook salmon has been relatively small compared to the fall chinook catch; however, the catch has remained relatively stable since about 1987. The ODFW regards spring chinook salmon abundance as depressed when compared with commercial landings during May through July in the 1930s (Nicholas and Hankin 1988). Spring chinook runs are maintained by hatchery fish produced at the Trask River and Whiskey Creek hatcheries.

The only long-term direct escapement (fish that have “escaped” the fishery) counts of the number of adult chinook salmon reaching the spawning grounds are “peak” count data collected on the spawning grounds. Peak counts are made during the spawning season by individuals who walk along the shore and count the number of spawners several times during the spawning season. ODFW began peak counts of fall chinook on the Kilchis, Wilson and Tillamook Rivers about 1950 and with a few exceptions has conducted them annually since. It should be noted that the peak count method of estimating spawning escapement has some serious limitations. Bodkin *et al.* (1995) reviewed the underlying assumptions in the peak count method, concluding that peak counts, as conducted by ODFW, are biased both in time and space and are often modified by a correction factor. One of the biggest problems with the peak count method was the selection of stream segments for monitoring. Instead of selecting stream segments randomly, the counts were routinely collected on those stream segments known to be more heavily utilized for spawning. Therefore, use of the peak count data for estimation of total numbers of spawners would result in an overestimation of the total numbers. The ODFW recognized the weakness in the peak count method, and since 1990 has randomized its sampling approach to spawning surveys. They have continued to collect peak count data at the standard survey reaches to allow comparison of the two methods.

Coho salmon

ODFW has identified coho habitat on the main stem of the Kilchis, the lower portions of both the North and South Forks, Little South Fork, Sam Downs Creek, and Clear Creek.

Coho salmon populations along the entire Oregon coast are now listed as threatened by the National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA) (58 FR 57770; 27 October 1993). According to Hasselman (1995), Tillamook Bay coho abundance and adult spawning escapement have shown significant rates of decline not generally observed for other Oregon coastal river basins in the central and north coast.

Historically, the Tillamook Bay Watershed was an important producer of coho salmon. Coho were harvested intensively in the Bay with gill nets from the late 1800s through 1961 when the gill net fishery was permanently closed. The annual gill net catch during the 1930s ranged from 24,590 to 73,974 and averaged about 46,000. After 1940, the gill net fishery declined while the ocean fishery increased. The decline in the gill net fishery may have been related, in part, to increased regulatory restrictions on the fishery. During the late 1980s, most of the harvest occurred in the ocean fisheries off Oregon and California. The total combined harvest of naturally produced Tillamook coho in the ocean (commercial and sport fisheries), estuary (sport fishery), and fresh water (sport fishery) during the late 1980s was estimated to average 3,500 coho annually (Bodenmiller 1995).

The recreational catch of coho in Tillamook Bay and its tributaries has been estimated since 1975, based on angler salmon/steelhead reporting tag returns. Harvest rates averaged 1,785 fish annually and have shown wide interannual variation.

Numbers of adult coho (mostly age 3) escaping to the spawning grounds have been indexed using the peak count method described above for chinook salmon. Surveys have been conducted by ODFW since 1981 on Sam Downs Creek in the Kilchis River basin and since 1950 elsewhere in the Basin. Peak counts (expressed as number per mile of stream surveyed) were relatively low in the mid-1950s, relatively high from about 1960 through the mid-1970s, and since about 1975 have remained low and variable. All-time lows were reached in the late 1980s and early 1990s. The lowest years for Sam Downs Creek have been 1981, 1983, 1987, 1989, 1990, 1992, 1993, and 1995, with the lowest year being 1990 (Klumph and Braun 1996). These data suggest that either the quality of freshwater habitat has declined drastically since about 1976 or that other factors (*e.g.*, poor ocean survival, overharvesting, influence of hatchery fish, or high estuarine mortality) are limiting the number of returning adults. As will be discussed below, some areas of the Tillamook River have probably experienced relatively heavy degradation of freshwater habitat quality but the majority of the Basin has had lighter impacts from human activities during the past 20 years.

Hatchery coho have been stocked in the Tillamook system, practically without interruption, since 1902. Returns of hatchery fish to the Trask River hatchery for the period 1985–1992 ranged from 1,245 to 10,174 with an average of 5,231 fish. The influence of hatchery fish on the naturally spawning populations is not known. However, it appears that the runs of natural spawners are earlier now than they were in the past, suggesting that hatchery fish have had an influence. Based on observations made during peak count spawning surveys, most Tillamook basin coho spawned during December in the decades of the 1950s and 1960s. But by the late 1980s peak spawning had apparently shifted to November. Until recently, it was the practice of hatcheries to take eggs from the first returning spawners. This practice selected for early spawners and over time has resulted in a shift toward earlier spawning runs of most coastal coho hatchery stocks, including the Trask River hatchery.

During the 1960s and 1970s, hatchery fish were released only into the Trask River and little change in spawn timing was noted. In the early 1980s, hatchery fish were released throughout the Tillamook basin (Miami, Kilchis, Wilson, and Tillamook). Chilcote and Lewis (1995) suggested that this event was responsible for the shift in spawn timing among the natural spawners. However, they recommended additional studies before making a definitive statement regarding cause and effect. If hatchery stocks have largely displaced the wild, naturally spawning coho in the basin, the population could be in a very precarious situation. Early spawning could subject incubating embryos in the gravel to high mortality due to bedload movements caused by early winter storms.

Chum salmon

The ODFW has identified chum habitat on the main fork of the Kilchis up through Reach 7, on the Little South Fork through Reach 12, and up Clear Creek through part of Reach 2, as well as the lower portions of several smaller tributaries.

Tillamook Bay historically supported the Oregon Coast's largest chum salmon fishery. During the 1930s and 1940s, catches of over 50,000 fish were not uncommon. Oregon is near the southern edge of chum salmon distribution which may, in part, account for the large interannual variability in run sizes that have been observed in Tillamook Bay streams over the years. The gill net fishery in Tillamook Bay held up longer than any of the other Oregon chum fisheries but was permanently closed in 1961.

Since chum salmon are not taken in the ocean troll fishery, the only recent catch data available for evaluating population trends are the estimates of recreational catch. The recreational catch of chum salmon has been estimated since 1969 based on salmon/steelhead reporting tag returns. Unfortunately, these data were not useful for estimating trends in the population because both fishing effort and regulations changed substantially over the period of record. Fishing for chum salmon with fly fishing equipment became popular in the 1980s on the lower Miami and Kilchis Rivers and fishing pressure increased greatly. In 1988, due to apparent declines in returning adults, the ODFW restricted chum salmon to catch and release on the Miami and Kilchis Rivers and closed all other streams to chum salmon fishing.

ODFW has collected peak counts of spawning chum salmon since 1948 in the Kilchis, Miami, and Wilson subbasins. Peak counts (number per mile) were relatively high through about 1954. Since 1954, the peak counts appear to have declined somewhat and have shown high interannual variability. Due to the very low counts on the spawning grounds since about 1992, concern has been growing that the chum population may be experiencing serious problems. The ODFW is watching the situation closely and if numbers do not increase in the near future may find it necessary to recommend closure of the catch and release fishery on the Miami and Kilchis Rivers (Klumph, R. personal communication 1997).

Chum salmon populations in the Tillamook Watershed have had minor supplementation by hatchery fish. Adults return to spawn at ages 2 to 7 with most returning at ages 3 and 4. Most of the spawning occurs in the lower reaches of the main river channels or in small flood plain streams tributary to the lower river channels. Information regarding recent trends in habitat conditions in these areas is not available.

Steelhead trout

Winter steelhead habitat is quite extensive in the Kilchis Watershed. It includes all of the larger tributaries of the Kilchis and the main stem.

The NMFS has listed steelhead trout along the Oregon Coast as threatened under the ESA, based on concerns that hatchery fish heavily supplement many of the runs and that survival of both wild and hatchery fish has declined recently (Busby *et al.* 1996). The listing petition (Oregon National Resource Council [ONRC] *et al.* 1994) requested ESA protection for the winter runs of steelhead in the Miami, Kilchis, Wilson, and Trask Rivers.

Two races of steelhead, “summer” and “winter,” live in the Tillamook Watershed. Winter steelhead are native to Tillamook Bay streams and are widely distributed throughout the basin. Summer steelhead were introduced to the basin in the early 1960s and were supported entirely by hatchery production (Braun, K. personal communication 1997). Since they are not native, summer steelhead are no longer managed by ODFW and are believed to be dying out (Knutsen, C. personal communication 1998). Winter steelhead generally enter streams from November through March and spawn soon after entering freshwater. Age at the time of spawning ranges from 2 to 7 years with the majority returning at ages 4 and 5.

No reliable information on the historic abundance of steelhead in Tillamook Bay streams is available. Steelhead were gillnetted commercially in Tillamook Bay from the late 1890s through the 1950s. However, harvest data for steelhead were not recorded in a reliable manner until after the fishery had been restricted to the early part of the steelhead run. Rough estimates of total coastwide steelhead run size made in 1972 and 1987 were similar (Sheppard 1972, Light 1987), suggesting that overall abundance remained relatively constant during that period. However, the proportion of hatchery fish in the runs appeared to have increased between the two estimates. Light (1987) estimated total run size for the major stocks on the Oregon Coast (including areas south of Cape Blanco) for the early 1980s at 255,000 winter steelhead and 75,000 summer steelhead. With about 69% of winter and 61% of summer steelhead of hatchery origin, Light estimated the naturally produced runs totaled 79,000 winter and 29,000 summer steelhead (note that most of the Oregon coastal summer steelhead are in the Umpqua and Rogue River systems).

The only information available for assessing trends in the abundance of steelhead runs to Tillamook Bay streams is angler salmon/steelhead report tags. The combined recreational catch of winter steelhead for all five subbasins and Tillamook Bay shows a declining trend since the early 1970s. The recreational catch has declined from a high of more than 20,000 in 1970 to less than 2,000 in 1993. The trend in the combined catch reflects the trends seen in each of the individual subbasins.

Sea-run cutthroat trout

Less is known about the present status of sea-run cutthroat trout than about any of the other anadromous salmonid species in the Tillamook Watershed. Sea-run cutthroat trout, the smallest of the anadromous salmonids present in the Watershed, have not been fished commercially. Although sea-run cutthroat trout are harvested in the recreational fishery, their numbers are not recorded on salmon/steelhead report tags. Therefore, determination of trends in abundance cannot be made on the basis of catch data. Beginning in 1997, sea-run and resident cutthroat trout angling regulations were changed to "catch and release" only (Klumph, R. personal communication 1997). Cutthroat trout spawn in small headwater tributaries in late winter and early spring when water conditions are generally poor for viewing. Age at spawning is highly variable (2 to 10 years) and individual adults may spawn more than once during their lifetime.

The only attempt to routinely count sea-run cutthroat has been resting pool counts made by ODFW staff since 1965 in conjunction with summer steelhead counts in the Wilson and Trask Rivers. Note that holding pool surveys were not conducted on the Wilson River in 1975 or 1978 or on the Trask River in 1975, 1977, or 1978. The resting hole count results are presented as average number of fish per hole to allow comparison from year to year due to differences in the number of holes surveyed. These data suggest that numbers of sea-run cutthroat trout in resting holes may have been somewhat higher before the mid-1970s than they have been since, particularly in the Wilson River. No further interpretation of the data is warranted.

Current Status of Estuarine Habitat

Studies conducted in other Pacific Northwest estuaries (Healey 1982, Simenstad and Salo 1982, Iwamoto and Salo 1977) have shown that the general behavior of anadromous salmonid species is quite consistent from estuary to estuary, although there are differences in detail. We relied on these general descriptions of juvenile behavior for identifying important habitat components in the Tillamook Bay Estuary because reliable site-specific information is lacking.

Chum salmon migrate seaward as fry, 30–40mm in length, and enter the estuary within a few days after emerging from the gravel spawning beds. Juvenile chum salmon were present in Tillamook Bay between March and June in monthly samples collected by the ODFW (Forsberg *et al.* 1975) between May 1974 and April 1975 (Table 9-2). Residence time of individual chum fry in the estuarine environment is variable (range 4–32 days) with the majority staying about 30 days (Simenstad and Salo 1982).

Table 9-2. Juvenile salmonids present at all sampling stations in the Estuary combined*

Species	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Chinook		18	266	1010	733	691	299		9	2	2	
Chum	169	7									14	310
Coho	12	1	2	2			12	2			3	16
Steelhead	1	7	3									
Cutthroat	2	3	1	4		5	1	1	1			

Note: *Total number of juvenile salmonids present at all sampling stations in the Estuary combined during the period May 1974 through April 1975. Sampling effort may not have been equal among all sampling stations.

Source: Adapted from Forsberg, B., J. Johnson and S. Klug. 1975. Identification, distribution, and notes on food habits of fish and shellfish in Tillamook Bay, Oregon. Fish Comm. of Oregon, contract report No. 14-16-0001-5456 RBS. 85 pp.

Healey (1982) found that chum salmon typically disperse several kilometers from the river mouth upon entry into the estuary. The first habitat occupied includes tidal creeks and sloughs high in the delta area, but other intertidal areas are also quickly colonized. During high tide, chum salmon fry congregate in the upper intertidal at the fringe of marshes, and penetrate deep into the marshes along tidal creeks. At low tide, the fry retreat into tidal creeks that retain flowing water at low tide and into delta channels. Eelgrass beds appear to be important both as a refuge from predators and as an area rich in invertebrate prey organisms.

Food availability in the estuarine environment may be an important limiting factor for chum salmon (Simenstad and Salo 1982, Gallagher 1980). Compared with the array of zooplankton potentially available as prey, juvenile chum salmon in other estuaries have been found to be highly size and taxa specific (Simenstad and Eggers 1981). They preferentially consume large, relatively rare harpacticoid (*Harpacticus* spp.) and calanoid (*Calanus* spp.) copepods from available epibenthic and neritic zooplankton, respectively. Although food habit studies of Tillamook Bay chum salmon have not been conducted, it is possible that fluctuations in the abundance of preferred prey species could play an important role in determining estuarine survival rates and subsequent run size.

Chinook salmon, because of their many juvenile life history patterns, have the most varied pattern of estuary utilization. Chinook which migrate seaward as fry colonize the estuary in much the same way as chum, first occupying tidal creeks high in the marsh area, and later the outer estuary. Unlike chum, chinook fry don't appear to occupy high salinity nursery areas. Some chinook fry may occur in the Tillamook Bay Estuary but previous sampling efforts (Cummings and Berry 1974, Forsberg *et al.* 1975) did not distinguish between fry and underyearling smolts. Most chinook in Oregon estuaries appear to enter as underyearling smolts in May and June (Reimers 1973). Forsberg *et al.* (1975) reported juvenile chinook present in Tillamook Bay from June through November with a few collected in January through March. Underyearling smolts are generally found in salt marsh habitat but mudflat, foreshore areas can be utilized for some time by larger underyearlings before they move into open water habitats (Stober *et al.* 1973, Simenstad and Eggers 1981). Yearling chinook (mostly from the spring run) move directly into neritic habitat without much utilization of salt marsh or other shallow habitat (Simenstad and Salo 1982).

Coho salmon smolts generally migrate seaward from April to June with peak movement usually occurring in May. Prior to entering the ocean, coho salmon may rear within the estuary for a short time. However, the actual use of the estuary by this species is not fully understood (Moore *et al.* 1995). During monthly sampling in Tillamook Bay between May 1974 and April 1975, Forsberg *et al.* (1975) caught a few juvenile coho during the period May through August, and in November, December, February, and March. Cummings and Berry (1974) sampled six locations along the main channel in Tillamook Bay from June through early September 1972 and found a few coho on all sampling dates. Further research is now being conducted to better understand coho out-migration.

Steelhead trout smolts appear to spend little time in estuaries and move quickly into the open ocean environment after migrating downstream in March, April, and May. Forsberg *et al.* (1975) reported finding a few steelhead smolts in May, June, and July catches of their 1974–1975 survey of Tillamook Bay fishes. None were caught during the June through early September 1972 sampling conducted by Cummings and Berry (1974). Utilization of the Tillamook Bay Estuary by underyearling steelhead has not been documented. However, downstream movements of underyearling steelhead during summer and early autumn have been observed in other estuaries (Zedonas 1992). It has been suggested that these movements may be in response to density dependent factors, indicating that the carrying capacity of the freshwater habitat has been exceeded (Zedonas 1992).

Most wild sea-run cutthroat trout smolts enter Pacific Northwest estuaries during April and May at age 2 to 4 years (Nicholas and Hankin 1988). Although not well documented, cutthroat trout probably utilize open water and channel habitat in estuaries. Studies of oceanic distribution of juvenile salmonids off the Oregon Coast indicate that juvenile cutthroat trout are present in off-shore waters from about May through August, but disappear from the catches in September (Pearcy *et al.* 1990). Apparently most cutthroat trout return to the estuarine or freshwater environment from mid- to late-summer (Gieger 1972, Loch 1982). Historically, sport fisheries targeted sea-run cutthroat trout in the Estuary and tidal reaches of rivers from about July through September. Present sport fishing occurs mainly in the rivers.

In addition to physical habitat, juvenile salmonids depend on the estuary for production of food organisms. Estuarine food webs are largely detritus-based systems. The watershed contributes particulate and dissolved organic matter, and salt marsh vegetation, eelgrass, and other types of submerged vegetation are important sources of detritus within the estuary. Juvenile salmonids (*e.g.* fall chinook) which rely heavily on detritus-feeding epibenthic invertebrates such as amphipods, isopods, and copepods therefore depend indirectly on eelgrass beds, salt marshes, and other areas of vegetation for their food supply.

Available information suggests that ample organic matter is available to supply animal populations in Northwest estuaries (Simenstad *et al.* 1984, Wissmar and Simenstad 1984, Wissmar 1986). However, in situations where populations are very abundant, local food resources may be limiting. It has been proposed that limited estuarine food resources may be partly responsible for declines in some natural salmon runs over the last century, as well as the lack of complete success of some hatchery stocks. When many juveniles at once reach the estuary (such as during a heavy natural outmigration or following release from a hatchery), they may reduce the size of the of the local invertebrate populations drastically. Prey resources are further limited, and recovery of the prey population is protracted, in areas where shallow flats, marshes and quiet channel habitat have been removed by dredging and channelization. Simenstad *et al.* (1982) hypothesized that in this situation the salmon may spend less time in the estuary. As smaller outmigrants to the ocean, they would then be more susceptible to open water predators. This will be addressed by the TBNEP-sponsored Comprehensive Conservation and Management Plan through restoration of additional habitat in the sloughs and the estuary.

Table 9-3 summarizes the habitat types and juvenile residency information for the five salmonid species. Of the five species, chinook salmon and chum salmon depend most on the estuary, followed by cutthroat trout. Most coho salmon and steelhead trout appear to use estuaries primarily as a migratory route and as a physiological transition zone for ocean residency.

Table 9-3. Primary estuarine habitats utilized by juvenile anadromous salmonids and approximate period of residency of individual fish

SPECIES	PRIMARY HABITAT UTILIZED					RESIDENCY (approximate range for individual fish)
	Salt Marsh	Eelgrass	Mud Flat	Tidal Channel	Open Water	
Chinook	X	X	X	X	X	weeks to months
Chum	X	X		X		days to about 1 month
Coho			X(?)	X	X	days to months
Steelhead			X(?)	X	X	days to a few weeks
Sea-run cutthroat		X	X(?)	X	X	weeks to months

Sources: Healey, M. 1982. Juvenile salmon in estuaries, the life support system. *In:* V.S. Kennedy, (ed.), Estuaries Comparisons. Academic Press, New York, N.Y.

Simenstad, C., and E. Salo. 1982. Foraging success as a determinant of estuarine and nearshore carrying capacity of juvenile chum salmon, *Oncorhynchus keta*, in Hood Canal, Washington. *In:* B.R. Miteff and R.A. Nevè, (ed.), Proc. North Pacific Aquaculture Symp. Rep. 82-2. Alaska Sea Grant Program, Univ. Alaska, Fairbanks, AK.

Iwamoto, R. and E. Salo. 1977. Estuarine survival of juvenile salmonids: A review of the literature. Rep. to Wash. Dept. Fish., Fish. Res. Inst., Univ. of Washington, Seattle, WA.

With the exception of water quality, little is known about the present status of Tillamook Bay's rearing habitat for juvenile salmonids. Water quality in the Bay remains good relative to the known requirements of anadromous fish. The major concerns regarding future water quality in the Bay are related to its capacity to absorb increased levels of nutrients and possibly toxic substances as the human population density in the Watershed increases.

Information on benthic and epibenthic invertebrate community structure and abundance would be helpful in evaluating present food resources for juvenile salmonids. A TBNEP-sponsored benthic and epibenthic invertebrate survey was conducted in 1996 (Golden *et al.* 1997). Preliminary results of the study indicate a diverse benthic community (154 taxa from grab samples collected throughout the Bay) with species richness (number of species) slightly higher in the lower Bay. Lower, middle, and upper portions of the Bay had similar ranges of species diversity, as did channels and flats. Conspicuously absent in the benthic samples was *Corphium salmonis*, an important prey species for juvenile salmonids in other estuaries (Golden *et al.* 1997). Detailed information on the density of benthic and epibenthic invertebrates at various locations in the Estuary is available in the final report for the invertebrate inventory.

Trends in important salmonid habitats within the Estuary can be seen by tracing changes in some of the key habitats through time. Historic maps and photographs of the Bay perimeter and bathymetric studies of the Bay morphology provide insight into some of the important changes that have taken place since settlement of the region by Euro-Americans in the mid-1850s. For a detailed account of historic changes in the Bay shoreline and bathymetry, the reader is referred to the TBNEP report prepared by Coulton *et al.* (1996) which documents the environmental history of the Tillamook Bay and Watershed. The following important changes have likely altered the quality and/or quantity of salmonid habitat.

- Intertidal habitat has been reduced by about 11% due to shoreline fills between 1867 and 1977. Most of the filling occurred on Bayocean Spit (57%), and around the river deltas (33%), with the remaining 10% in the Port of Garibaldi.
- Extensive tidally influenced brackish and freshwater wetlands have been lost. Large areas of tidal wetlands that were connected with the Trask, Wilson, Kilchis, and Tillamook Rivers to the south and west of the City of Tillamook were present when the Bay was first mapped in the mid-1850s. Construction of levees and dikes in the late 1890s and early 1900s converted most of these wetlands to pasture for dairy cattle.
- Most of the existing tidally influenced wetlands have been created during the past 50 years due to delta growth at the mouths of the Kilchis, Wilson, Trask, and Tillamook Rivers. Delta growth has been very rapid since the 1950s and has extended up to 3,000 feet (914m) beyond the shoreline conditions that were present in the 1930s. The delta has been colonized primarily by salt marsh vegetation. No studies have been conducted to determine whether rearing juvenile salmonids are directly utilizing the newly created salt marsh habitat.
- The new delta formations at the mouths of the Kilchis, Wilson, Trask, and Tillamook rivers have developed at the expense of mudflat habitat.
- Periodic bathymetric mapping of the Bay since 1867 indicates that the Bay is becoming shallower and that the deeper tidal channels, particularly in the southern half of the Bay, have been filling in and are less extensive than they were historically. Juvenile salmon rely on the network of tidal channels for access to the remaining intertidal salt marsh habitat and for cover during low tide. Rapid filling of the southern Bay could potentially reduce the connectivity between intertidal salt marsh habitat and the subtidal channel habitat.

- LWD was abundant in the Estuary and in the tidally influenced portions of river channels when the region was first settled in the 1850s. Juvenile anadromous salmonids use LWD in the estuary as cover and refuge from predators, particularly during low tide. Much of the LWD in Bay tidal channels and lower river channels was actively removed between the late 1800s and 1920.
- The Bay entrance and main channels for navigation have been dredged periodically since the mid-1890s. Before dredging began, four main tidal channels cut through the 6-mile long Bay. During the late 1890s, three pile-dikes were constructed and dredging connected two of the channels. This reduced the natural channels to two main tidal channels, each wider and deeper than the original four. A secondary result was the shoaling of the western half of the Bay. The main navigation channel was dredged regularly up to the 1970s. Impacts of dredging on salmonid habitat in the Bay include temporary loss of benthic macro invertebrate food organisms, changes in the tidal prism and salinity intrusion, and modifications to the natural sediment dynamics of the Bay.

From the above review and analysis of historic maps of the area, it is clear that both tidally influenced wetland habitat and intertidal mud flat habitat have been substantially reduced since the mid-1880s. During the last 50 years, considerable new salt marsh habitat has been created in the south end of the Bay due to delta formation associated with high sediment input from the Basin. Recent floods have probably accelerated this situation. The new salt marsh does not replace the quantity of lost marsh and wetlands and probably provides lower quality habitat than the lost mature marsh. Large portions of the new salt marsh are grazed by cattle resulting in impacts to habitat quality. In general, the complexity of the estuarine habitat has been reduced. Complex structure provided by large woody debris has been removed and the connections between river channels and their flood plains have been severed (except during periodic large floods) through the construction of dikes and levees; these losses are probably permanent. Sediment from the Watershed appears to be filling the upper portion of the Estuary and reducing the amount of deeper channel habitat. It should be noted that in 1974 state environmental experts advocated dredging the upper Bay and rivers in order to restore marine life in these areas following changes caused by the 1972 floods (Wick 1972). However, the COE determined that dredging of the southern Bay channels was economically infeasible because the channels would probably have to be dredged each year and dredging would not prevent tidal flooding (Gilkey 1974). Today, environmental experts no longer advocate dredging as a viable alternative for reducing the effects of sediment on estuarine biota.

In addition to providing food and shelter for juvenile anadromous salmonids, the Tillamook Bay Estuary also provides a migratory route and physiological transition zone for adult salmonids returning from the ocean. Adult salmon, steelhead, and sea-run cutthroat trout spend varying lengths of time in the Estuary prior to river entry. Adults often hold in the deep holes in the Estuary or the tidal zone of the rivers. Coho salmon, and spring and fall chinook salmon may spend from a few days to several weeks in the estuarine and brackish water environment. Low flow conditions in the rivers during the fall migratory period of coho and fall chinook salmon can delay their upstream migration. Chum salmon generally enter the Estuary later in the fall when flow conditions in the rivers are higher and move relatively quickly to the spawning grounds. Steelhead trout also enter the Estuary during periods when river flow is relatively high and move quickly into fresh water (Dawley *et al.*1986). Cutthroat trout spend variable lengths of time in the Estuary and tend to utilize the tidal freshwater areas of the lower rivers prior to upstream migration.

While in the estuarine environment, adult anadromous salmonids are subject to mortality from sport fishing (discussed previously) and from predation by marine mammals, including harbor seals and sea lions. Harbor seal (*Phoca vitulina richardsi)* and California sea lion (*Zalophus californianus californianus*) populations in the Northwest have increased dramatically since they became protected under the Marine Mammal Protection Act of 1972 (Table 8-3). Seals and sea lions are known to prey on salmonids and on species that are important salmonid prey (Olesiuk and Bigg 1988; Olesiuk *et al.* 1990). The literature includes few estimates of harbor seal annual consumption. Harvey (1987) addressed the question of harbor seals' total consumption of fish and particular prey eaten. Based on previously reported food habit studies, he estimated that salmonids numerically comprised fewer than 1% of the fish consumed, but accounted for 11% of the total biomass. A comparative study of the diets of harbor seals and California sea lions in Puget Sound indicated that salmonids comprise a higher percentage of the diet of California sea lions than harbor seals (National Marine Mammal Laboratory [NMML] 1996). Salmonid remains were found in only 2% of harbor seal scats but 15% of sea lion scats. The California sea lion diet included adult, jack, and juvenile salmonids whereas only adult salmonid remains were found in the harbor seal scat (NMML 1996). The remaining diet of these pinnipeds is primarily bait fish (*e.g.*, herring, smelt, and anchovy) and invertebrates (squid).

Predation rates of harbor seal and sea lions on anadromous salmonids in Tillamook Bay have not been studied. However, an investigation of harbor seal seasonal abundance and food habits conducted in Tillamook Bay and Netarts Bay between June 1978 and November 1981 indicated that harbor seal predation was probably not very high, at least at that time (Brown and Mate 1983). Harbor seals were most abundant in June through August, the pupping and molting period. Numbers of harbor seals declined to annual low levels from September through December, when most of the adult salmon were passing through the Estuary. Analysis of the seals' feces indicated that they were feeding mainly on abundant smaller fishes such as surf smelt, northern anchovy, shiner perch, English sole, and Pacific herring.

Salmon Critical Habitat Areas

The areas of important habitat for salmon consist of the core areas identified by the Oregon Plan for Salmon and Watersheds (OPSW), the spawning/rearing/migration areas identified for the Tillamook hydrologic unit by ODFW, and the migration corridors identified by ODFW that are needed to connect these habitat areas with the ocean or spawning areas. Of the 25 Kilchis reaches surveyed by ODFW, there are six that do not fit in the above description (Reaches 3, 16, 19, 20, 24, and 25); the remaining 19 reaches will be covered by this evaluation.

ODFW uses a set of 11 characters to determine the condition of stream habitat for salmonids (see Table 3-2 for the character descriptions and benchmark values). The 11 characters and the figures that present the Kilchis ratings for those characters in map form are:

- the percentage area of the channel in pools (Figure 9-1),
- the number of channel widths between pools or pool frequency (Figure 9-1),
- the residual pool depth during summer low-flow conditions (Figure 9-1),
- the width to depth ratio for riffles (Figure 9-2),
- the sand/silt/organic matter (SSO) percentage content of the riffle substrate (Figure 9-3),
- the gravel percentage content of the riffle substrate (Figure 9-3),
- the shading of the stream (Figure 4-1),
- the number of large woody debris (LWD) pieces per 100m (Figure 3-2),
- the volume of LWD per 100m (Figure 3-2),
- the number of key pieces of LWD per 100m (Figure 3-2), and
- the future ability of the riparian to supply high-quality LWD to the stream channel or recruitment potential (Figure 3-2).

The benchmarks for these characters have been used to assign ratings of good (2 points), fair (1 point), or poor (zero points) based on the measured value for the character. When the ratings are summed across all eleven characters, the range for the summary rating is zero to 22. For the summary rating, a value of 16.6 or above is good, between 5.5 and 16.6 is fair, and below 5.5 is poor. All of the reaches fall in the fair category, with a range of 6.0 to 14.2 for the summary values. The strongest and weakest habitat characteristics for the different river and stream sections are summarized in the following paragraphs.

Kilchis Mainstem

The mainstem has eight surveyed reaches (Reaches 4–11) with summary ratings ranging from 8.0 to 13.0 and an average of 10.8. The characters that rated high were the riparian shade, pool area, residual pool depth, the pool frequency, and the riffle gravel. The low characters were the remaining four riparian characters, and the riffle width/depth ratio. Overall, the riparian characters were mostly low, the pool characters were high, and the riffle characters were low to moderate.

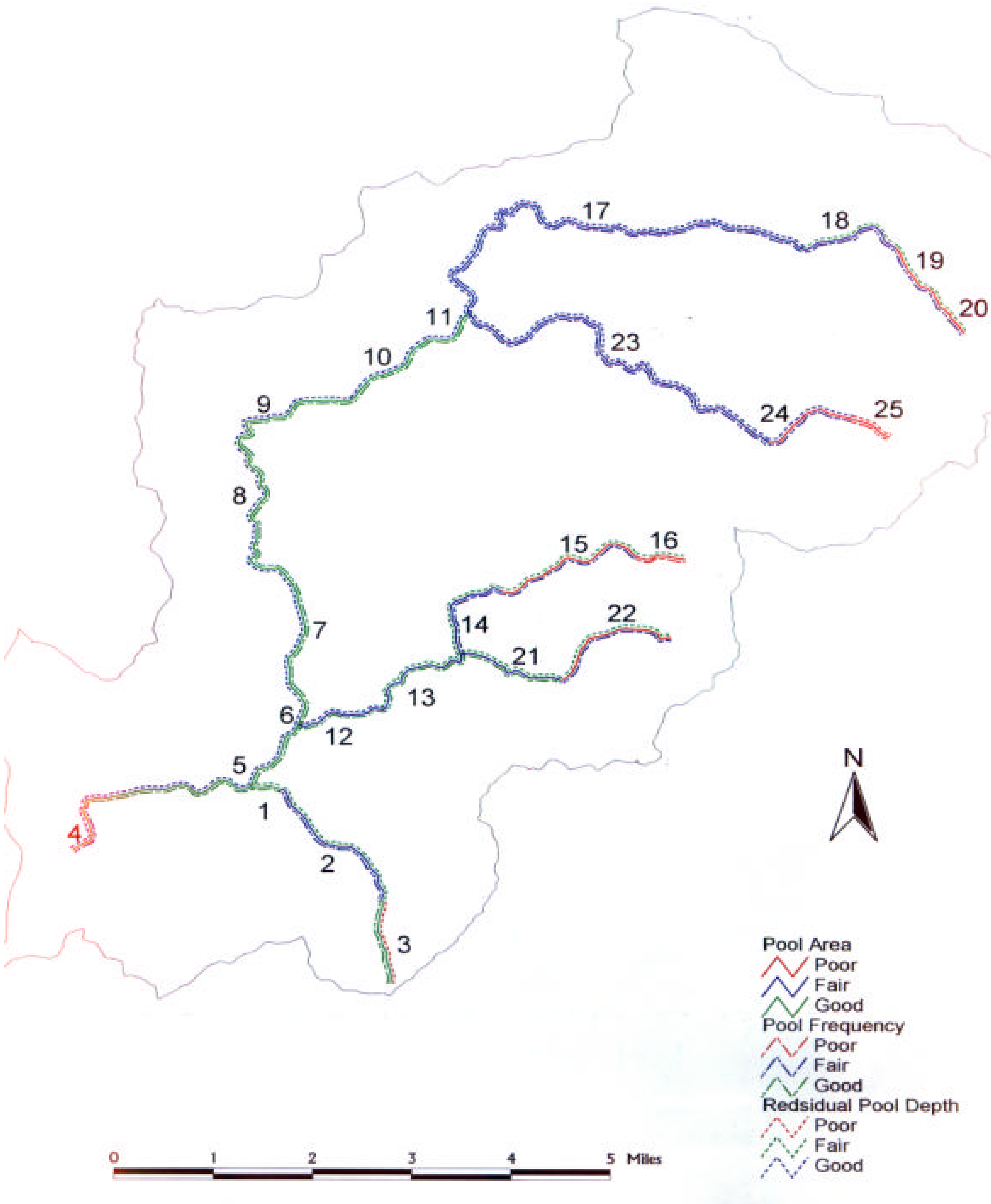

Figure 9-1. Stream pool characteristics for the surveyed reaches of the Kilchis River. (Source: TBNEP GIS layer KILHAB)

Figure 9-2. Ratio of riffle width to stream depth for the surveyed reaches of the Kilchis River. (Source: TBNEP GIS layer KILHAB)

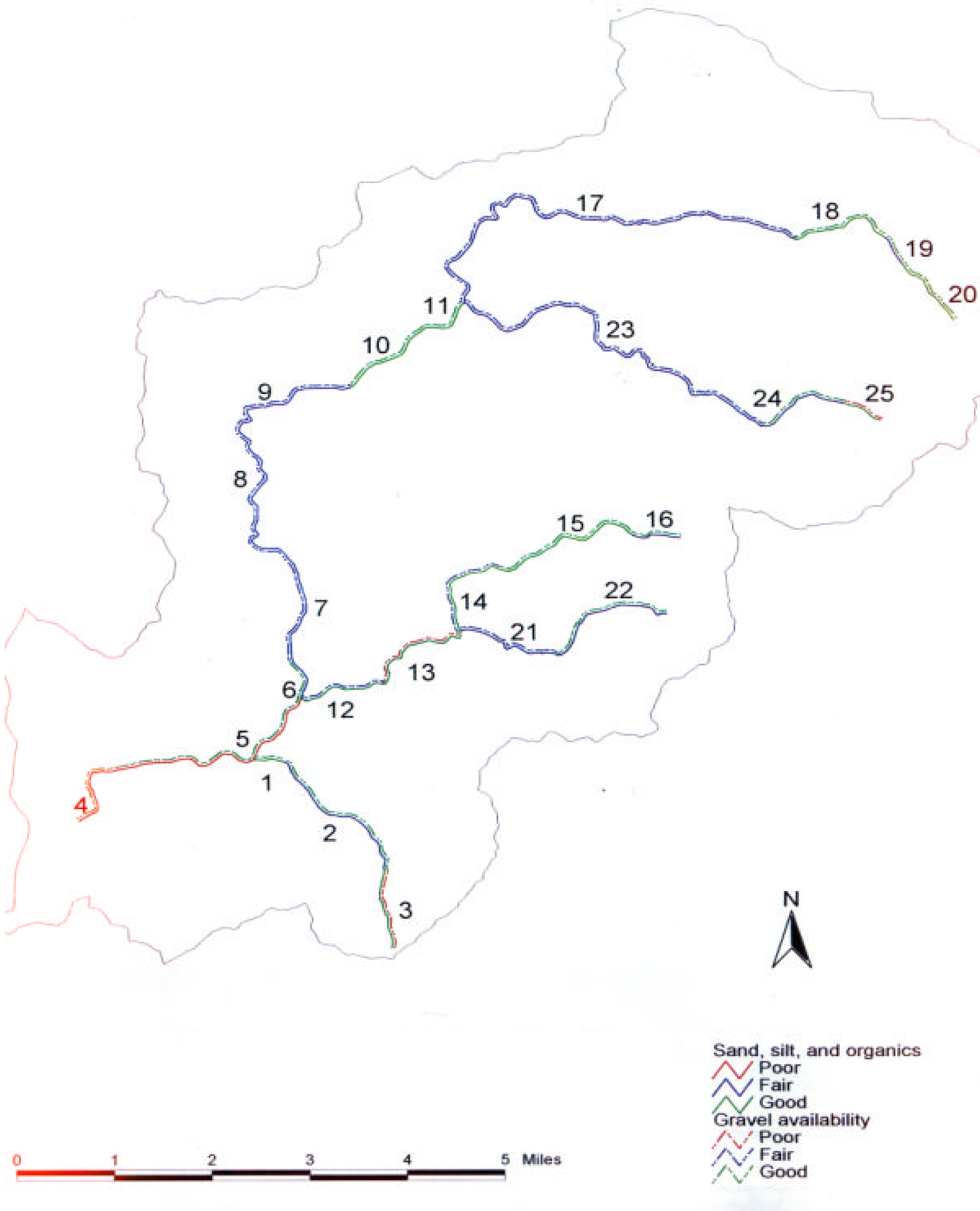

Figure 9-3. Substrate composition of stream riffles for the surveyed reaches of the Kilchis River. (Source: TBNEP GIS layer KILHAB)

Little South Fork

This fork has four reaches (Reaches 12–16) with summary ratings ranging from 7.7 to 14.0 and an average of 9.3. The characters that rated high were the SSO content of riffles, and pool frequency. The low characters were the LWD number of pieces, volume, key pieces and riparian recruitment potential. Overall, the riparian characters were mostly low, the pool characters were moderate to high, and the riffle characters were moderate to high.

North Fork

This fork has two reaches (Reaches 17 and 18) with summary ratings of 7.4 and 15.0. The characters that rated high were riparian shade, residual pool depth, the SSO content of riffles, and the gravel content of riffles. The low characters were the LWD key pieces and recruitment potential. Overall, Reach 17 had low to moderate scores and Reach 18 had moderate to high scores.

South Fork

This fork has three reaches (Reach 23–25) with summary ratings of 11.0, 14.0, and 6.0. The characters that rated high were riparian shade and residual pool depth. The low characters were LWD key pieces and riparian recruitment potential. Overall, Reach 23 had low to high riparian characters, moderate to high pool characters and moderate riffle characters.

Sam Downs Creek

Sam Downs has two reaches (Reaches 21 and 22) with summary ratings of 9.0 each. The characters that rated high were LWD volume and pool frequency. The low characters were riparian shade and recruitment potential, and pool area. Overall, the riparian characters were low to high, the pool characters were low to high, and the riffle characters were moderate.

Clear Creek

Clear Creek has two reaches (Reaches 1 and 2) with summary ratings of 10.8 and 11.0. The characters that rated high were riparian shade, pool area, pool frequency, the SSO content of riffles, and the gravel content of riffles. The low characters were LWD key pieces and riparian recruitment potential, and the width/depth ratio of riffles. Overall, the riparian characters were low to high, the pool characters were moderate to high, and the riffle characters were moderate to high.

Habitat Needed For Salmonid Life Stages

The Kilchis River was surveyed in the summer of 1995 and the results were used to create a database and associated GIS layer. Using that layer, queries were made regarding where salmonid habitat would be located for each life stage. The results of the queries will be specific to the Kilchis Watershed, and therefore potentially be a more accurate assessment of where fish might be than other surveys. However, the survey only covers the mainstem and tributaries of the Kilchis and does not reach into the lower portion that flows through private agricultural land. Therefore the extent of the coverage is limited. The results were compared to separate GIS layers generated by ODFW and OPSW that show “best professional judgement” regarding the location of salmonid habitat and “core habitat” areas, as defined by OPSW. The information from the survey was combined with temperature data from HOBO monitors that are located in the Kilchis, as described in Chapter 6.

In general, there is available habitat for each stage of each salmonids life history in the Kilchis Basin. However, improvements could be made that would create more favorable conditions for populations that are in decline. Current habitat quality is low to moderate and often is lacking in at least one component. Two characteristics that stand out are the lack of rearing habitat and the lack of cover for spawning adults and young juvenile fish of all species. From the Kilhab GIS layer, the attribute “Woodscore”, shown in Figure 6-2, indicates that there is little wood complexity in streams. All areas are rated in the bottom two-thirds of quality and many are very poor. This corresponds with a survey (Coastal Salmon Restoration Initiative [CSRI], unpublished conference proceedings) of state professionals asking them to indicate the most significant factors limiting natural production of salmonids. Those factors that rated high for North Coast streams include gravel quantity and quality (affected by instream wood complexity), temperature for spawning adults, channel complexity (affected by wood complexity), streamflow, temperature, and flood plain and wetland availability for rearing habitat. It can be assumed that available cover for all juveniles is a priority problem in the following discussions.

Fall Chinook

The GIS queries identified habitat that matched closely with ODFW identified habitat (Figure 9-4). The area below the confluence of North and South Fork is not selected because it is deeper than the preferred water depth for spawning. The largest obstacle to juvenile fish appears to a lack of instream cover, such as woody debris, and minimum temperatures, with the majority of the HOBO monitors showing temperatures below the preferred range.

Spring Chinook

Conditions for spring chinook are very similar to fall chinook salmon. The GIS query identified habitat that matched closely with ODFW habitat (Figure 9-4). Again the area below HOBO 12 is not selected because it is deeper than the preferred water depth for spawning.

Figure 9-4. Probable spawning areas for fall and spring chinook in the Kilchis watershed.
(Source: TBNEP GIS shape files CFSPAWN, CSSPAWN)

Coho

Query results match ODFW and OPSW habitat closely except for two differences. Sam Downs Creek and the Little South Fork are identified as OPSW core areas (Figure 9-5). They were not selected from the TBNEP database due to the gradient being greater than 5%. Core areas identified in the upper tributaries to the North Fork were not selected as they were not surveyed. Much of the Kilchis could be available as spawning, incubation, and rearing habitat for coho if temperature and wood complexity conditions could be improved.

Chum

Chum present an interesting case. ODFW and OPSW both identify chum habitat as being within the lower 1/3 of the Kilchis watershed, however additional reaches such as Sam Downs Creek and the Little South Fork have habitat that is physically suited to chum, but is currently though to be unused by this species. Emmet *et al.* (1991) indicates that chum can travel extensively, up to 2500 km upstream, but often 200 km upstream; 200 km encompasses all of the Kilchis watershed. The GIS query shows a lower watershed area similar to that identified as core habitat by ODFW and also an upper watershed area, that may or may not be appropriate for chum (Figure 9-5). Additional monitoring of actual stream usage by chum (spawning ground surveys) could be warranted to ensure that the full range of their use is understood. Rearing areas for chum are typically in the estuary. Therefore estuary conditions, rather than stream conditions, will determine the ability of chum to rear successfully.

Winter Steelhead

The ODFW habitat layer shows extensive use of the Kilchis watershed by winter steelhead (Figure 9-6). No OPSW core areas are identified within the watershed boundary for this species. The GIS query results show similar findings with use ranging from lower reaches to the uppermost reaches of the north and south fork. Spawning winter steelhead face significant difficulties with maximum temperatures. Again, juvenile fish face difficulties with rearing habitat due to a lack of complexity of instream wood. Otherwise significant amounts of the Kilchis waterways would be available as winter steelhead habitat. Steelhead habitat could also be improved by adding thermal cover (*i.e.*, planting riparian conifers), which would benefit every fish species.

Cutthroat

Little current information regarding preferred habitat in the Kilchis for cutthroat trout could be found. It is likely that similar conditions, *i.e.*, lack of rearing habitat and some temperature difficulties, would be found for this salmonid species as well.

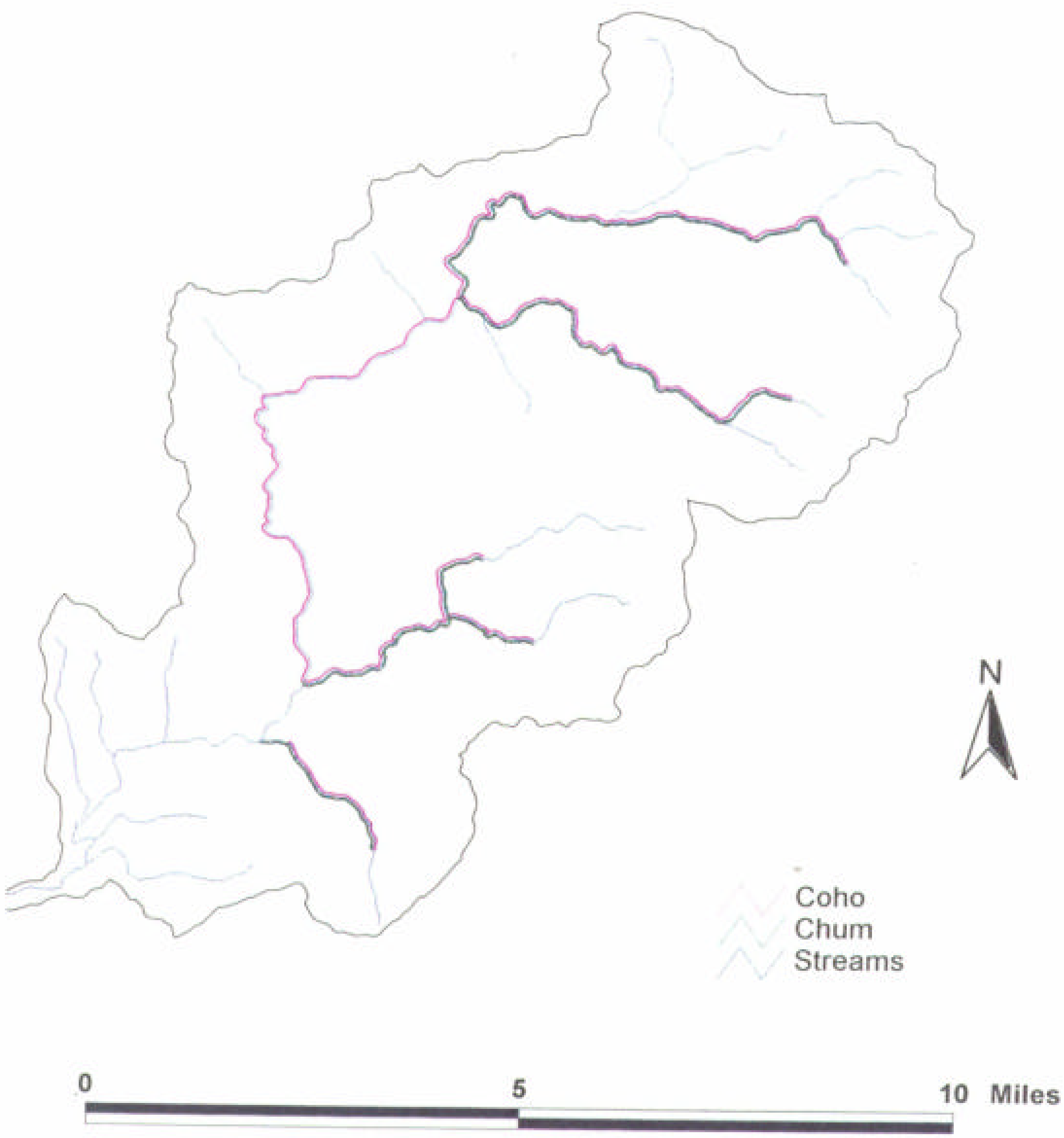

Figure 9-5. Probable spawning areas for coho and chum in the Kilchis watershed. (Source: TBNEP GIS shapefiles COHOSPAWN, CHUMSPAWN)

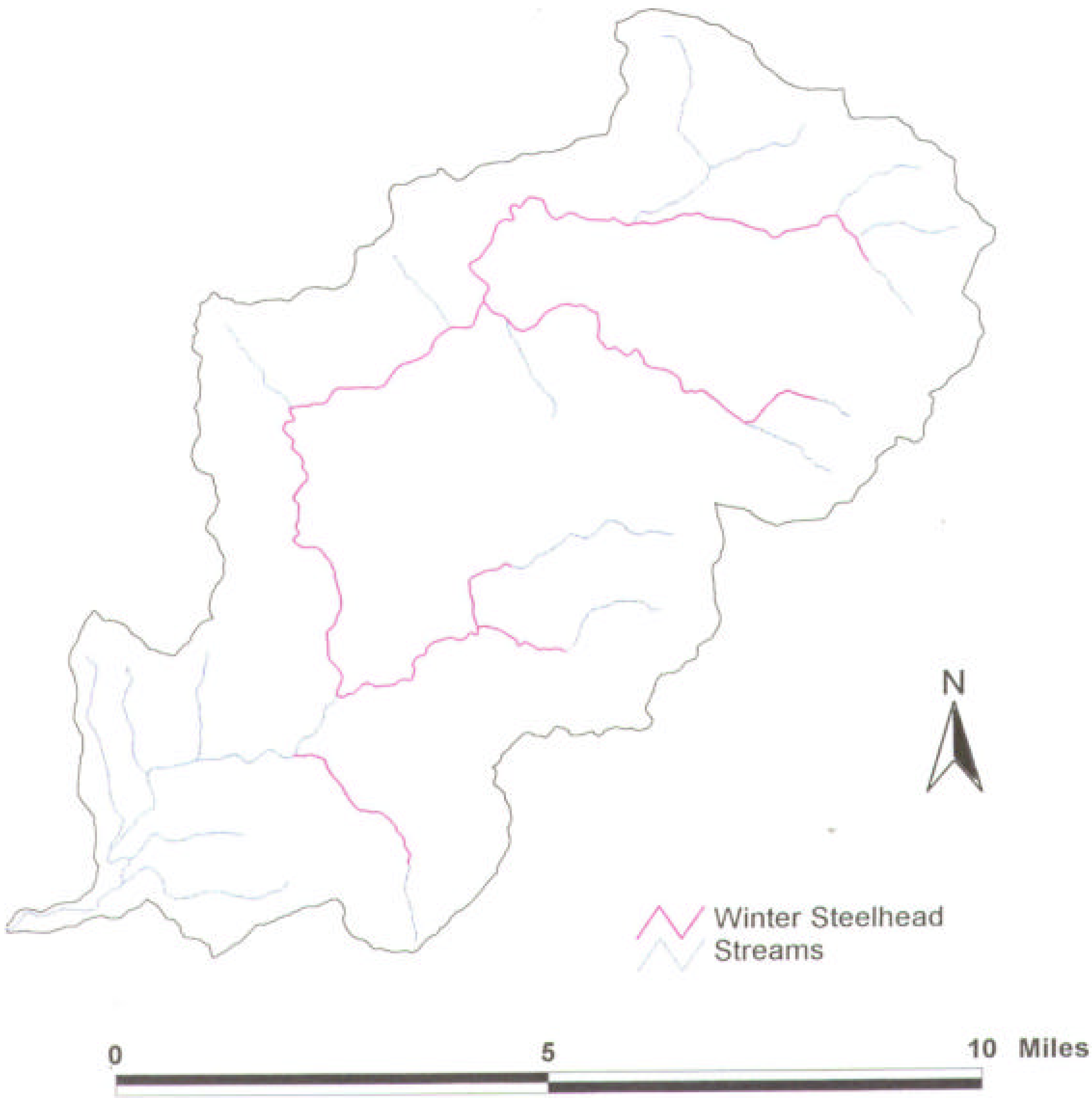

Figure 9-6. Probable spawning areas for winter steelhead in the Kilchis watershed. (Source: TBNEP GIS shapefile STWSPAWN)

In general, potential or current habitat exists for the five salmonid species. The current problems with salmonid habitat are summarized below:

1. Poor thermal cover results in wide temperature swings which could be harming the survival rate of several species of salmonids, particularly those that spend significant amounts of time in freshwater portions of the watershed.
2. Wood complexity is lacking in most of the watershed main tributaries. This leaves juveniles vulnerable to predation and lowers survival rates.
3. Little or no riparian cover along the lowest portions of the surveyed reaches results in very poor habitat conditions (*i.e.*, lack of cover from predators, high water temperatures, low inputs of insects as food), potentially blocking access to higher portions of the stream.

Channel Modifications Affecting Habitat

Information for this section was taken from the ODFW habitat surveys and information supplied by Randy Stinson of Tillamook Soil and Water Conservation District (SWCD) (ODFW 1995, Stinson, R. personal communication 1997). Figure 9-7 shows the location of areas that may have bank or channel modifications. Twenty-two sites are identified as having rip-rap banks in the report by Randy Stinson.

Information taken from the Fish and Wildlife habitat survey shows 15 possible human caused bank disturbances: two from riprap, five from bulldozer activity, six from bridge and bridge abutments, one from an off-highway vehicle (OHV) crossing, and one that showed both bulldozer activity and riprap. Because of the close proximity of some of the disturbances, only 11 are apparent on Figure 9-7. Riprap and bridge abutments prevent bank undercutting, which provides some fish habitat. Bulldozer activity and OHV crossings may be indicators of very disturbed soil; a source of sediment into fish habitat. All of these modifications are in salmon migration habitat.

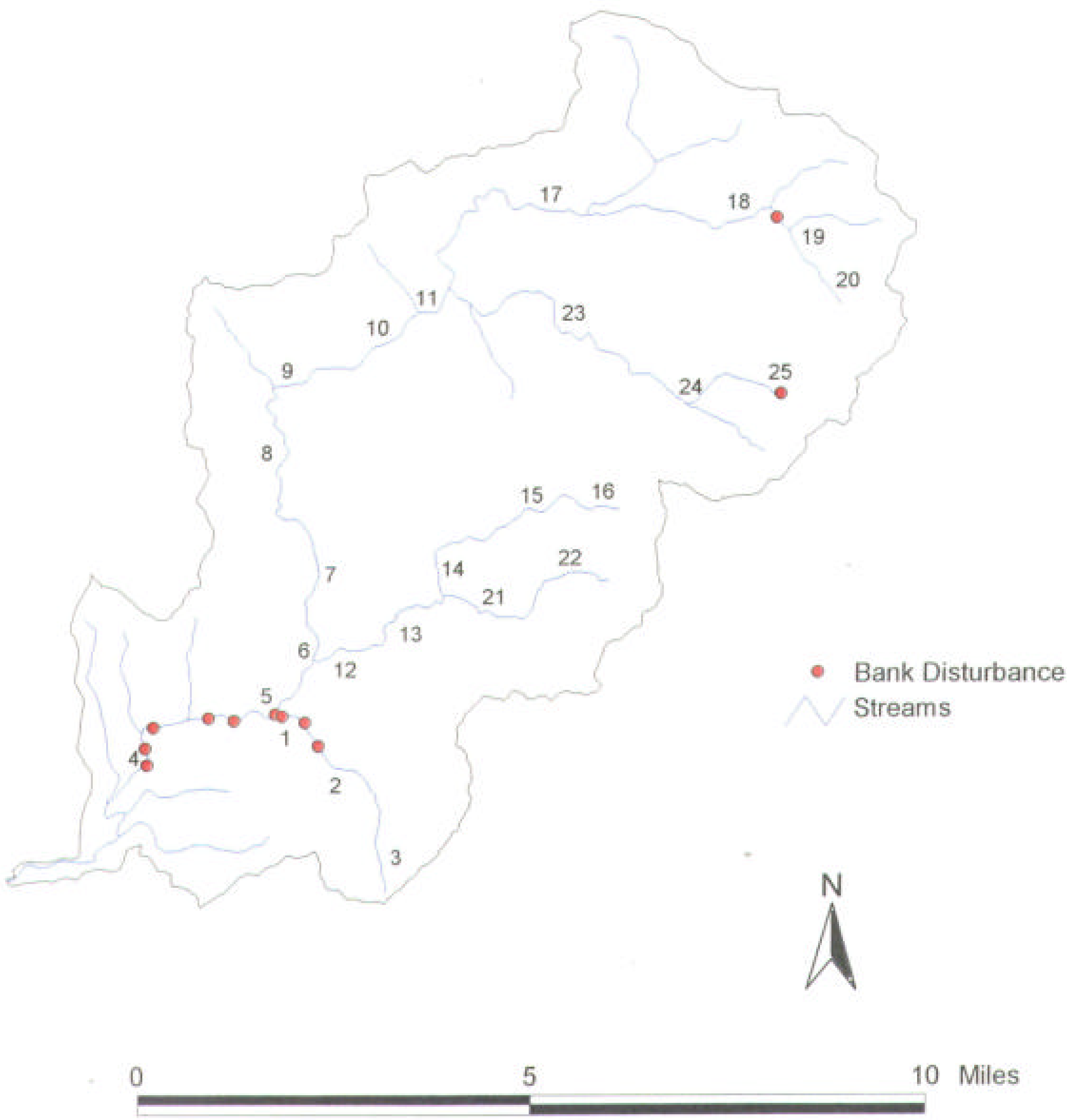

Figure 9-7. Bank disturbances for the surveyed reaches of the Kilchis River. (Source: TBNEP GIS layer KILHAB)

Features Blocking Fish Passage

The ability to move throughout a watershed is an important factor in the life history of many fish species, particularly salmonids. Human impacts have created barriers to this movement which reduce the amount of habitat available, and in turn have significantly impacted fish populations (Bodkin *et al*. 1995). Barriers can block some salmonid life stages while not affecting others. Salmonids can be blocked as migrating adults, migrating juveniles or as foraging resident fish. Factors that affect a barriers ability to block fish are jump height, water velocity, and culvert length; the allowable range for these three factors differ for each species and life stage. One substantial type of barrier has been impassable culverts, which accounted for 96% of the barriers identified in a 1995 study (OPSW 1997a). Although the ODF road survey inventoried the location and type of all culverts in the Kilchis watershed, the culverts were not rated for their ability to pass fish. The culverts in the agricultural portion of the watershed have also not been surveyed for their ability to pass fish. For this reason, all culverts in the Kilchis watershed should be systematically surveyed to determine if they block passage for adult or juvenile fish. Additional obstacles include impassable natural features (waterfalls or debris jams) and dams.

Nine possible barriers were identified in the Kilchis watershed; they are shown on Figure 9-8 and numbered for easy reference. Information for this topic was taken from three GIS layers: NCSTSITE, which identifies one barrier in the Kilchis watershed on Coal Creek (Number 1); KILHAB, the ODFW Stream Habitat surveys, which identifies five possible barriers (Numbers 5–9); and CULVERTS, a layer prepared by ODFW for the Oregon Department of Transportation (ODOT) and hereafter referred to as the ODOT study, which identifies only those culverts judged to be impediments to fish passage. Three culverts were identified in the Kilchis watershed by the ODOT study (Numbers 2–4). In total, approximately 9.2 miles of salmon habitat are upstream from these barriers.

The information available for analysis only covers upland areas that are not privately owned. To sufficiently determine all barriers to fish movement, a comprehensive survey of lowland stream areas, including those crossing private lands, would have to be made.

Coal Creek

An ODFW layer shows that coho and chum salmon use the lower portion of this stream up to the barrier for spawning habitat. Additionally, this creek is identified as a “core area” by OPSW for chum salmon. The barrier identified by NCST (Number 1) could potentially be blocking access to additional habitat.

Clear Creek

The ODFW stream habitat survey lists a debris jam (Number 5) that could be a potential barrier in Reach 3 in Clear Creek. Clear Creek has been identified by ODFW as coho spawning habitat

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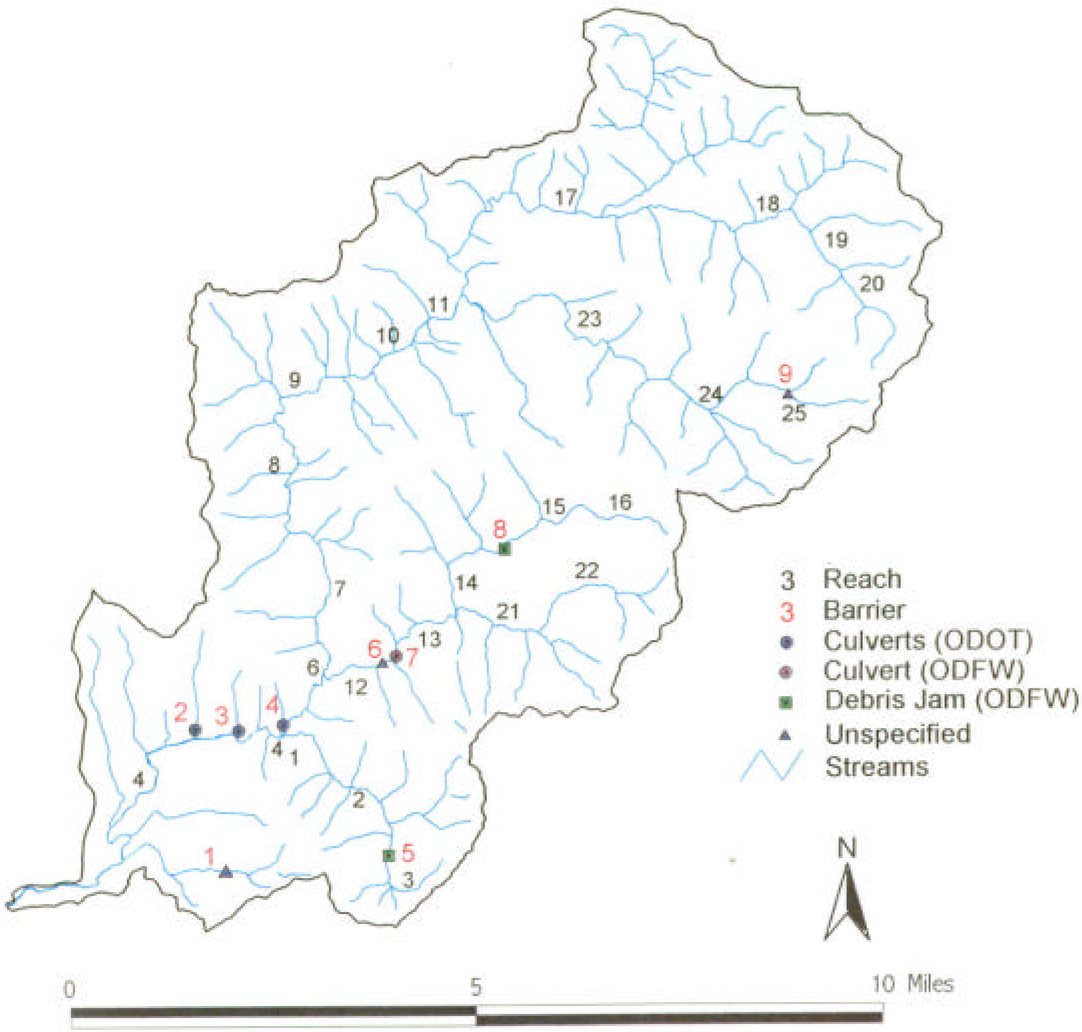

Figure 9-8. Barriers to salmon movement in the Kilchis watershed. (Source: TBNEP GIS layers CULVERTS, NCSTSITE, KILHAB)

Little South Fork

Three barriers are identified by the ODFW stream habitat survey in this stream (Numbers 6–8). Barrier number 8 is a debris jam, Number 7 is a corrugated metal culvert and barrier Number 6 is not specifically identified. These are located in ODFW identified coho spawning habitat and number 8 is located in OPSW identified *core area habitat* for coho. Additionally, barriers 6 and 7 are in habitat identified as chum and fall chinook spawning habitat as well as OPSW *core area habitat* for chum. The ODOT study does not identify the culvert (Number 7), indicating that it could have been repaired by the time the ODOT study was implemented (June 1997) or that different criteria were used to identify problem culverts.

South Fork

The ODFW stream habitat survey lists a barrier (Number 9) near the head of this tributary. This probably affects very little salmon habitat and is not in any core area or specifically identified spawning habitat.

Myrtle Creek

The ODOT survey lists a culvert (Number 2) near junction of Myrtle Creek and the Kilchis River as presenting a difficulty for cutthroat and possibly coho. Priority for repair is listed as low as the habitat quality above the culvert is low.

Unnamed Tributary

A culvert (Number 3) on a small creek intersecting the Kilchis River just east of Myrtle Creek is identified as a problem for cutthroat by the ODOT study. Again, priority is low for repair due to the low quality habitat upstream from the culvert.

Unnamed Tributary

A culvert (Number 4) on a small creek intersecting the Kilchis River is identified as a problem for cutthroat by the ODOT study. Again, priority is low for repair due to the low quality habitat upstream from the culvert.

Prioritizing Enhancement Work

The ODOT study prioritized repair work based on the quality of habitat above the culvert barrier and the type of fish populations that would be affected. Of the five types of salmonids that use the Kilchis watershed, coho and chum populations are considered to be in the poorest condition. Taking this into consideration, those areas that would benefit coho and chum should be the highest priority for repair. The barrier on Coal Creek (Number 1) affects both coho and chum, therefore it is recommended that this area be one of the highest priority sites investigated and enhanced if possible. Also, the barriers on the Little South Fork (Numbers 6 and 7) affect spawning areas for both coho and chum and are potentially blocking access to core area habitat for coho. This area, however is identified as over 5% slope, and may not be an ideal candidate for enhancement work; the area should be investigated. Sites 5, 8, and 9 are moderate priority and sites 2–4 are low priority.

Critical Lowland Areas Needing Protection and Restoration

Several studies and various benchmark values outlined previously in this document seem to point to a few general problems with the health of this watershed. Kilchis streams are deficient in riparian habitat capable of providing shade and LWD input. In order to improve this, substantial efforts should be made to develop riparian areas and maintain them over many decades to a point in which they will be capable of providing LWD. In the short term, adding LWD to streams where access allows such activity, would be beneficial.

The majority of the lowland portion of the Kilchis mainstem is very deficient in riparian stands. The restoration of riparian communities adjacent to the mainstem is a high priority. Additionally, there is a general lack of off-channel rearing habitat in this portion of the watershed. Lowland off-channel habitat should be protected where it currently still exists and restored or constructed throughout the freshwater and tidal portions of the mainstem and its associated sloughs.

Unscreened Water Diversions

Information was taken from the ODF stream habitat survey. No other information was available for analysis. Two unscreened diversions were identified in the habitat survey. They are located in Reaches 4 and 6, shown on Figure 9-9. One diversion is shown as being within the boundaries of the Kilchis County Park, the other is located on private property owned by Simpson Timber Company. These should be confirmed and screened if possible.

To accurately assess the condition of water diversions in the Kilchis River, a float study in the fall should be conducted. The objective of the float study would be to identify unscreened diversions and then contact the landowners to request voluntary screening of the diversions. ODFW has a cost share program for screening diversions.

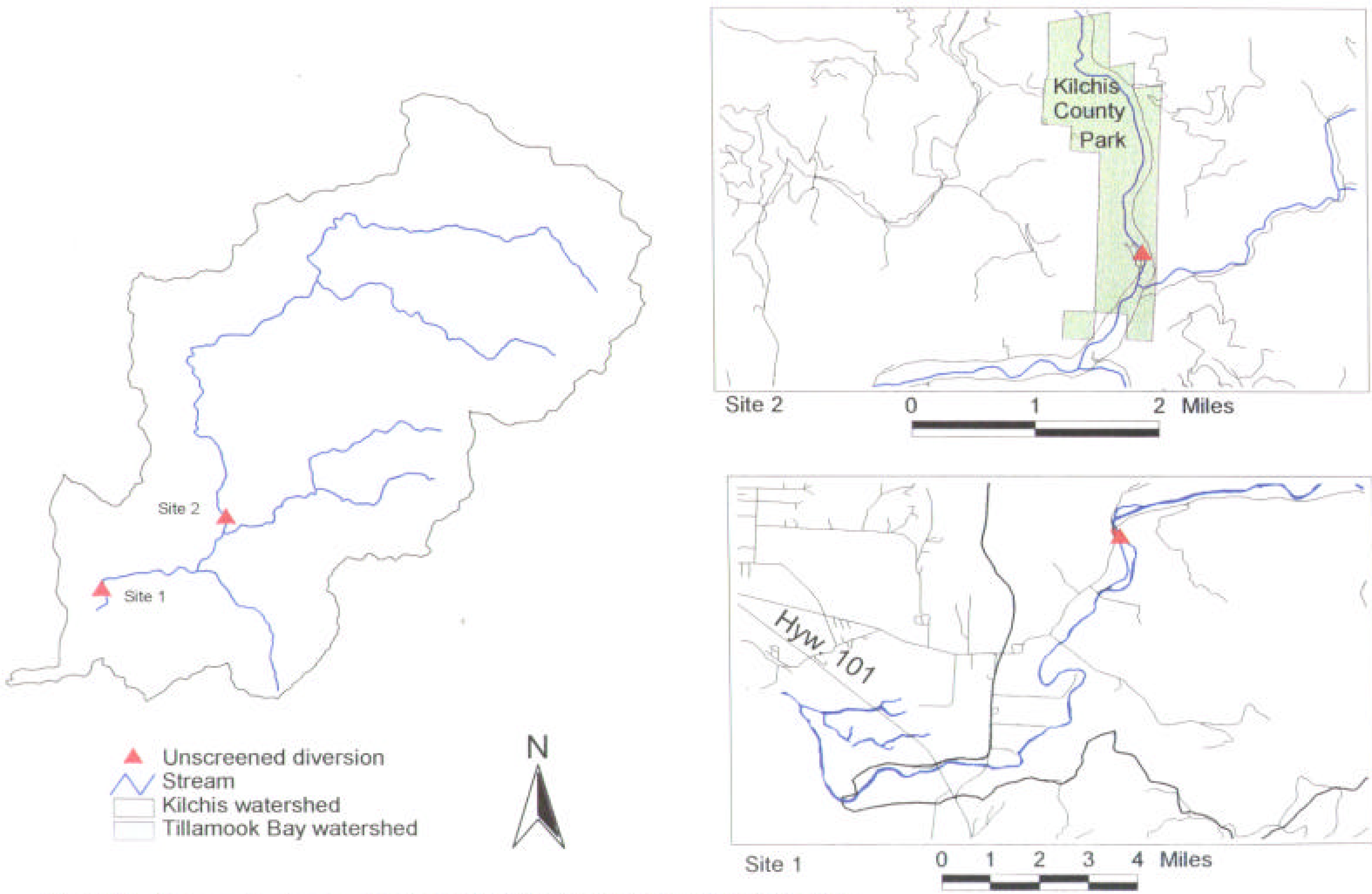

Figure 9-9. Unscreened water diversions in the Kilchis watershed. (Source: TBNEP GIS layer KILHAB)

Endangered Plant and Animal Species

A list of endangered plant and animal species found in Tillamook county was extracted from the statewide list compiled by the Oregon Natural Heritage program. The list and explanations of the codes used in it is contained in Appendix B.

Wildlife Species Residing In The Watershed

A list of wildlife species identified as naturally occurring in the Kilchis Watershed area was compiled from The Atlas of Oregon Wildlife (Csuti, et. al., 1997). The list is contained in Appendix C.

10.0 SYNTHESIS

Introduction

This section presents a brief synthesis of the findings of this study for the four priority issues. The issues are: sediment and its impacts on beneficial uses; water quality and its impacts on beneficial uses; the decline in salmonid populations; and flooding and its impacts.

Sediment

The Kilchis Watershed has a fairly high natural, background rate of erosion. This is due to several topographic, geologic and climatic factors. These factors include:

- the mountains are geologically young and slopes are very steep,
- some of the geologic formations are more prone to slope failure and some of the soils are highly erodible,
- topography concentrates subsurface water in concave landforms such as the steep headwalls of small streams,
- the region has high rainfall, and
- soil parent materials weather rapidly to recharge potential failure sites.

Human activities that have increased the erosion rate include: forest fires caused by logging operations or other people, timber operations in the uplands and bank modification in the lowlands. Timber operations include road building and its long term effects, salvage logging operations, and regular harvest operations. Bank modifications include riparian vegetation removal, farming activities, mining activities, and installation of riprap and bridge abutments.

The Kilchis Watershed experienced five forest fires in under 35 years (1918, 1933, 1939, 1945, and 1951). The fires increased erosion through the loss of vegetative cover and root reinforcement of the soil; and the heat from the fire making the soil somewhat hydrophobic and thus prone to surface erosion.

Following the fires, the watershed was salvage logged. At the time of the logging, there was no Forest Practices Act to regulate logging practices and minimize their impact on the environment. Unregulated road building, skid roads in stream channels, and other practices led to further increases in the landslide and surface erosion rates. Approximately 1400 landslides were mapped by ODF employees from aerial photos for the period 1954–1996. At its peak, the erosion rate is estimated to have reached ten times the natural background level of erosion (Mills, K. personal communication 1998). The debris flows resulting from the landslides and heavy sediment inputs scoured the beds of the majority of the stream channels in the watershed and had extensive impacts on fish habitat and fish populations.

Much of the huge load of sediment generated by the fires and salvage logging passed through the lower portion of the watershed and into the bay. In the low-gradient portion of the watershed the sediment temporarily accumulated and formed plugs in the river channel. As a result, the river channel migrated to the side, eroded the banks and widened considerably. The river has recovered somewhat and is now narrower than it was during the peak of the sediment transport period. The high level of erosion went on for many years, but has now subsided back to a level much closer, but still above, the natural background level. Unless there is another major disturbance, erosion is expected to stay at or below current levels.

Much of the sediment reached the bay along with major inputs of sand from the Bayocean Spit breach (1952–1956). The sediment that did not immediately flush through the bay filled in the channels, accreted saltmarsh along the southern shores, smothered benthic organisms, and had numerous other ecological effects. The bathymetry of 1956 shows the vastly simplified and shallower bay of that heavy sediment input period. The bathymetry of 1995 shows the bay recovering through deepening and widening of the channels, development of a more extensive and interconnected channel network, and generally deeper water than during the peak sediment input period.

Continual sediment inputs to the stream system are needed to replenish spawning gravels, which wash through and out of the system over time. The sediment that is currently entering stream channels in not being retained long enough in the upper to middle portions of the watershed, where it is needed to provide spawning beds for coho, chinook, cutthroat and steelhead. The gravel retention is low in these stream reaches because of the lack of LWD and boulders in the stream channels. The current lower levels of sediment input and poor retention will eventually also affect the gravel bars in the floodplain reaches, which are used by chum for spawning and have historically been mined for gravel.

The majority of sediment that is currently being produced is from road-related landslides. ODF has conducted a Forest Road Hazard Inventory that evaluated all drivable and walkable roads in the watershed. The inventory resulted in a prioritized list of roads that need work to lower their risk of causing a landslide or other type of erosion. ODF is upgrading the road system as funds permit and has already made major improvements to the road network in the Kilchis.

Water Quality

Water quality in the Kilchis River and its tributaries and sloughs are important for its impacts on fish populations and water contact recreation. The potential water quality issues are temperature, bacteria, nutrients, turbidity and dissolved oxygen.

The water temperatures in the Kilchis Watershed are frequently outside the preferred ranges (either too high or too low) of the individual salmonid species (Tables 6-2 and 6-3). These outlying temperatures occur primarily during the spawning and rearing stages, but there are a number of cases in the incubation stage (particularly for cutthroat) as well. Scattered instances of lethal temperatures were also recorded for all three life stages. The majority of the lethal temperatures were maximums and occurred during the rearing stage. The minimum temperatures occur because the riparian stands are dominated by alders, which drop their leaves in winter and provide no thermal cover for the streams. The maximum temperatures occur almost exclusively in the agricultural/rural residential portion of the watershed where riparian stands are absent or severely degraded; the lack of shade allows direct solar insolation to heat the water.

The Kilchis has lower bacteria contamination than any of the other four rivers in the basin. Despite the relatively low levels, its bacteria content still exceeds state standards for water contact recreation approximately 40% of the time in the agricultural/rural residential portion of the watershed. The sources of the bacteria and their relative contributions have not been positively identified, but the two main contributors are probably dairy farming and failing septic systems. The lack of well developed riparian stands in the agricultural/rural residential portion of the watershed allows contaminated surface runoff to enter stream channels without first being filtered by riparian vegetation. Tillamook County recently surveyed many of the septic systems in the County and identified many of the failing systems so that they can be repaired or replaced. Suboptimal farm management practices, contribute to manure contamination of surface flows reaching stream channels. The NRCS has been working with farmers to write farm management plans that implement best management practices which reduce manure runoff. SWCD and Tillamook Cooperative Creamery Association are working with willing landowners to fence-off and plant riparian areas along some of the stream channels.

Nutrient and turbidity levels in the Kilchis do not exceed state standards at the present time. There are currently no programs to address these issues in the Kilchis Watershed.

Preliminary testing has found dissolved oxygen to be a potential problem in Hathaway Slough. The Slough could provide valuable rearing habitat for several species of salmonids if the water quality was acceptable. The low levels of dissolved oxygen in the summer are probably a result of: manure runoff providing nutrients; stagnant water concentrating those nutrients; high water temperatures promoting algal growth; and high temperatures lowering the water's capacity to hold oxygen. All of these factors will have to be addressed to increase the rearing habitat quality. Manure contamination can be reduced through best management practices and riparian/buffer strip plantings. Stagnant water can be addressed through reconnecting the slough at the upper end to flood flows and modifying the tide gates at the outlet. Riparian plantings and greater water column exchange will also lower water temperatures.

Flooding

Riverine overbank flooding occurs in the lower Kilchis Watershed about as often as it does for the other four rivers in the Tillamook Basin. However, the Kilchis floodplain has a much lower human population density than do the Wilson and Trask floodplains. Flooding of the Kilchis impacts primarily agricultural operations and a small number of rural residents. The objective of flood mitigation efforts then is to minimize the impacts of flooding through first understanding the factors affecting flooding and then working to modify those factors to reduce economic impact without harming habitat values.

The three sediment zones of a watershed are from top to bottom the storage, transport and deposition zones. It can take many years for sediment generated in the storage zone to reach the deposition zone. The remaining large bedload of coarse sediment produced by past disturbances in the Kilchis Watershed is moving down through the lower transport and the deposition zones. The river lacks the energy needed to move the majority of this bedload beyond the deposition zone and into the bay, so it will accumulate in the deposition zone. This zone roughly corresponds to the inhabited portion of the watershed, where land values are the highest. If the bedload is allowed to move into the deposition zone and remain there, it would cause bed aggradation, lateral channel shifts, bank erosion and increased flooding. Eventually a braided, marshy channel through most of the floodplain would be the result. The side effects would include loss of high-value land, increases in water temperature and changes in fish habitat values (both positive and negative). Coarse sediment has been mined from the deposition zone since at least the 1940's. Currently, gravel mining is halted through a moratorium while its effects on chum spawning are being investigated.

This situation results in the formation of gravel plugs in the deposition zone, one of which caused extensive bank erosion in the winter of 1997–98 around River Mile 5. This required the removal of the plug and extensive bio-engineered stabilization (rock barbs, riparian plantings) of the area. A channel migration zone needs to be determined by agency personnel working with landowners and the public. Within this zone, composed of purchased or leased private lands, the river would be allowed to meander and erode banks. A monitoring program would need to be established to track the meandering and the deposition of coarse sediment in the deposition zone. Information collected by the program would be used to recommend **if** gravel should be removed, and to develop guidelines for the timing, quantity and mining method used. The monitoring program could be a reactivation of the discontinued NRCS/SWCD program with the addition of ODFW staff to give input on chum habitat needs, and DSL staff to give input on regulatory issues. It is possible that some of the monitoring program could be carried out by volunteers from a watershed council or other civic group.

Currently the main channel of the Kilchis is partially plugged by gravel close to its confluence with the bay. This causes the majority of the flow to divert into Squeedunk Slough and enter the bay at a different location. This situation affects flooding through decreasing the conveyance capacity of the main channel and slowing the draining of the floodplain as flood waters recede. The COE is planning to construct a hydrologic model of the Tillamook Basin, which would allow the investigation of different channel modification scenarios to determine if they would reduce flood impacts while not harming habitat values. Limited dredging of the lower Kilchis is one scenario that should be investigated using the model when it is completed.

A second possible hydrologic modification project would be the reconnection of Hathaway Slough to flood flows. This could be accomplished at the upper end through an excavated swale and water control structure, and at the bottom end through tidegate modification. The swale would also provide additional salmonid habitat during periods of flooding and year around habitat for amphibians and other aquatic dependent species. The modified tidegates would allow greater fish access to and from the slough as well as improved drainage following flooding. The project design would have to be tested using the COE hydrologic model to determine its effectiveness and effects on habitat. This project could conceivably increase the total channel capacity in the floodplain for conveying flood flows and for draining water off the land as floodwaters recede. It would also improve water quality in the slough for rearing salmonids through increased water column exchange and flushing of sediments. If this project were implemented, then the sediment in the slough should be monitored to determine if the increased flows are scouring out the accumulated fine sediment. If the scouring doesn't occur, then it may be advisable to eventually dredge portions of the slough to expose the buried spawning gravel beds for use by chum and to increase the conveyance capacity of the slough channel.

Salmonid Populations

The spawning densities of salmonid species are roughly comparable between the five rivers of the basin with the exception of chum, which are strongest in the Miami and Kilchis Rivers (Klumph, R. personal communication 1998). Coho are of particular concern because of their recent "threatened" listing status. In 1997, coho had 2–3 spawners per mile, which is very low and presents real cause for concern. In contrast, fall chinook have approximately 40 spawners/mile and a healthy population. Traps set to monitor smolts leaving the Little South Fork caught many coho fry, which were leaving the system prematurely; this may indicate that there was a lack of suitable habitat (Dalton 1998). The chum populations are relatively healthy in the Miami and Kilchis watersheds, but they are weak in most other coastal rivers.

All six of the salmonid populations present (fall and spring chinook, coho, chum, winter steelhead, and cutthroat trout) as well as other aquatic dependent species will benefit if habitat conditions are improved in the watershed. The work needs to be focused on coho, chum, steelhead and the two lamprey species because they are the populations most at risk in the region. The following protection, enhancement and restoration measures were designed to address both salmonid/fish populations and the other priority issues in the watershed simultaneously. They are listed in order from high to moderate priority.

Protection of existing high-quality habitat should have the highest priority of all projects. It is more cost effective than either enhancement or restoration and it helps to maintain existing habitat already populated with fish. Management activities upstream and upslope of the core areas should be evaluated for the risk they pose to the streams and management adjusted accordingly to minimize those risks. The ODF program to identify and prioritize erosion hazards on roads and then upgrade them is very important to the protection of existing habitat values. Private forest landowners should be encouraged to adopt their own version of this program. High quality habitat in the tidal area such as the riparian stand on Squeedunk Slough and the salt marshes beside the bay should be protected through conservation easements or acquisition.

Riparian stands in the floodplain and along tidal channels need to be restored through planting a variety of native tree and shrub species. The areas should fist be fenced to exclude cattle from the riparian zone. Grass filter strips could also be established on the landward side of the riparian areas to increase the effectiveness of filtering the contaminated overland runoff. The highest priority should be given to public lands, to gaps in the riparian corridor devoid of any trees at all, and to willing landowners. Additional plantings could be established on: existing riprap to increase habitat values in those areas; and on very wide gravel bars with unrooted willow or cottonwood "post" cuttings to initiate revegetation and stabilization of those areas.

Instream enhancement of habitat needs to be performed throughout the watershed. There are two types of work to be accomplished: addition of LWD and boulders to increase structure and retention; and construction of off-channel habitat such as alcoves to provide fish with refuge from flood flows. The Thom-Moore report listed potential reaches for instream enhancement (Table 3-4) in the Kilchis. Since funding is limited and there are reaches listed for all of the rivers in the basin, only the Priority 1 and 2 reaches should be investigated for detailed project planning. The KWG used information in Table 10-1 and from other sources to determine which reaches would be most beneficial to add LWD to for coarse sediment retention. The highest priority reaches are: 1, 2, 11, 12, 17 and 23. A proposed gravel mine located on a river terrace of the Kilchis has the following two major benefits: this would shift mining from instream to the terrace; and when the mine was finished it would be converted to a large alcove for salmonid habitat.

Table 10-1. Summary of Channel Habitat Types, Habitat Quality Parameters, Salmonid Species Present, and Known Hazards for the Surveyed Reaches of the Kilchis Watershed

Stream	Reach #	CHT type/%	Shade	Gravel	Pools	Current LWD	Potential LWD	Fish Spp. Present	CSRI Core	Known Habitat Hazards
Clear Creek	1	FP3	2	2	5	0	0	chf,chu,coh,stw	yes	
Clear Creek	2	MV	1.8	2	3	2	0	chf,chu,coh,stw	yes	
Clear Creek	3	SV	2	0	4	5	0.2	coh,stw		barrier (debris jam)
Mainstem	4	FP2	1	2	5	0	0	chf,chs,chu,coh,stw	yes	
Mainstem	5	LC	0.6	2	6	0	0	chf,chs,chu,coh,stw	yes	
Mainstem	6	LC	2	2	6	0	2	chf,chs,chu,coh,stw	yes	
Mainstem	7	LC	2	1	6	0	0.7	chf,chs,coh,stw		
Mainstem	8	MM	2	1	6	0	0	chf,chs,coh,stw		debris flow (from Slide Cr)
Mainstem	9	MM	2	1	6	0	0	chf,chs,coh,stw		
Mainstem	10	MC	2	2	6	0	0	chf,chs,coh,stw		
Mainstem	11	MC	2	2	6	0	0	chf,chs,coh,stw		
Little S.F.	12	LC	0	1	5	0	0	chf,coh,stw	yes	2 barriers (culvert, unknown)
Little S.F.	13	MC	0.5	0	4	0	0	chf,coh,stw	yes	
Little S.F.	14	MC	0.7	1	3	0	0	chf,coh,stw	yes	
Little S.F.	15	MV 66%/SV 33%	1	2	2	6	0	chf,coh,stw	yes	barrier (debris jam)
Little S.F.	16	SV 33%/VH 66%	2	2	1	4	0	chf		
N.F.	17	MC	0.4	1	4	0	0	chf,stw	yes	debris flows (two on tributaries
N.F.	18	MC	2	2	3	5	0	chf,stw	yes	
N.F.	19	MV	2	2	2	4	0	chf,stw	yes	
N.F.	20	MV	2	2	2	4	0			
Sam Downs Cr.	21	MV	0	1	4	2	0	chf,coh,stw	yes	road washout
Sam Downs Cr.	22	MV 66%/SV 33%	0	2	2	4	0	chf,coh,stw	yes	
S.F.	23	MC	2	1	4	2	0	chf,coh,stw		
S.F.	24	MV	2	2	3	5	0	coh,stw		barrier (unknown)
Range			0–2	0–2	0–6	0–6	0–2			

Additional enhancement in suitable reaches of the uplands could be accomplished through the relocation of beaver to these areas. Reaches with suitable gradients, food supplies, and lack of hazards (*e.g.*, adjacent roads to flood, culverts to plug) could be easily identified. Whenever beaver were trapped in lowland areas following landowner complaints, they could be released in the identified reaches. Beaver ponds are particularly good habitat for coho rearing as well as providing habitat for other aquatic species, settling sediment from the water column, and temporary storage of water during high flows.

Some barriers to fish migration have been identified in the watershed, but only a small percentage of the culverts have been surveyed for fish passage. Of the identified barriers, those with the highest priority for replacement are Numbers 6, 7 and 8 (Figure 9-8). They are located on the Little South Fork and affect a coho core area and extensive habitat. The entire set of upland and lowland culverts need to be systematically evaluated for fish passage, prioritized for replacement, and the work begun to replace those blocking crucial habitat or the largest amount of potential habitat.

Riparian stands throughout the upper watershed need to be interplanted with conifers to supply coniferous LWD in the long term. In order for interplanting to be a success in the dense alder stands, girdling of patches of alders would be required before planting. This type of project could be accomplished in two stages with the first being prison inmates from the Wilson work camp doing the girdling under ODF supervision, and the second being citizen volunteers doing the planting.

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Appendix A. Streams of the Kilchis Watershed.

Table presents stream name (where available), what the stream is tributary to, the section where the tributary confluence is located, the channel confinement and gradient for the first reach above the confluence, and the total length of channel (in feet) for each channel habitat type (CHT) for that stream, and the approximate total length of the stream channel.

Stream	Stream	Tributary	Stream Origin	Confinmt.	Gradt. %		Channel		Habitat		Types		Stream
No.	Name	To Stream	1/4 Section	1st Reach	1st Reach	FP2/3	LC	MM	MC	MV	SV	VH	Total
	Clear Ck.	MAIN	TINR9WS33SW	CA	2	2000				6000	5600	2400	16000
	Mainstem	ESTUARY	T1SR10WS23SW	CT	1	21000	14800	18200	8000				62000
	Lit. Sth. Fk.	MAIN	T1NR9WS28SE	CH	1		5500		8200	8000	5200	3000	29900
	Nth. Fk.	MAIN	T2NR9WS35SE	CH	2				31700	6500	2800	2400	43400
	Sam Downs	LSFK	T1NR9WS26NE	CH	4					10200	4000	2500	16700
	Sth. Fk.	MAIN	T2NR9WS35SE	CH	3				21000	7000	2500	3500	34000
100	Coal	MAIN	T1SR9WS7NE	US	1	2000				2800	3000	3200	11000
101		MAIN	T1SR9WS7NE	US	1	2500				2000	2200	2500	9200
102	Murphy	MAIN	T1SR9WS6SW	US	1	2800				4000	3000	2800	12600
103	Mapes	MAIN	T1SR9WS6NE	CH	4					3000	1200	3800	8000
104		MAIN	T1NR9WS31SE	CH	32	600						1400	2000
105	Myrtle	MAIN	TINR9WS32SW	CH	12	800				2500	1000	2000	6300
106	Thomas	MAIN	T1NR9WS32SE	CH	15		1000				2000	1500	4500
107		MAIN	T1NR9WS33SW	CH	27							3000	3000
108		MAIN	T1NR9WS33SW	CH	23							3000	3000
109		MAIN	T1NR9WS33SW	CH	23						800	2500	3300
110		CLEAR	T1SR9WS4NE	CH	19							3500	3500
111		CLEAR	T1SR9WS3NW	CH	27							3800	3800
112		CLEAR	T1SR9WS3NW	CH	27							3600	3600

Stream	Stream	Tributary	Stream Origin	Confinmt.	Gradt. %		Channel		Habitat		Types		Stream
No.	Name	To Stream	1/4 Section	1st Reach	1st Reach	FP2/3	LC	MM	MC	MV	SV	VH	Total
113		CLEAR	T1SR9WS3NW	CH	27							2800	2800
114		CLEAR	T1SR9WS3SE	CH	18							4000	4000
115		CLEAR	T1SR9WS3SE	CH	9						2500	8000	10500
116		CLEAR	T1SR9WS3SE	CH	9						2400	2000	4400
117		CLEAR	T1SR9WS10SE	CH	20						2400	2000	4400
118		CLEAR	T1SR9WS10SE	CH	27							2000	2000
119		CLEAR	T1SR9WS10SE	CH	18							3000	3000
120	Watertank	MAIN	T1NR9WS33NE	CH	17	800						2500	3300
121	Shirley	LSFK	T1NR9WS27SE	CH	20							3500	3500
122	Iris	LSFK	T1NR9WS27SE	CH	12					1000	2500	800	4300
123		LSFK	T1NR9WS27SE	CH	10					0	2000	800	2800
124		LSFK	TINR9WS26NW	CH	16						1500	1600	3100
125	Jody	LSFK	T1NR9WS26NE	CH	18						800	5000	5800
126	Ruth	SD	T1NR9WS25NE	CH	14						1000	4800	5800
127	Rose	SD	T1NR9WS25NE	CH	11						1500	2500	4000
128	Ann	SD	T1NR9WS25NE	CH	12						1000	8500	9500
129		SD	T1NR9WS19SE	CH	16							3200	3200
130		SD	T1NR9WS19SE	CH	13							1500	1500
131	Dietz	LSFK	TINR9WS23NE	CH	13						2200	3000	5200
132		131	TINR9WS23NE	CH	29							2000	2000
133		LSFK	TINR9WS23NE	CH	11						2200	3400	5600
134		133	TINR9WS14SE	CH	32						2200	3200	5400
135		LSFK	TINR9WS13SW	CH	16						1500	3000	4500
136	School	MAIN	T1NR9WS28SE	CH	20							2800	2800
137	Washout	MAIN	T1NR9WS28NE	CH	12						1500	3400	4900

Stream	Stream	Tributary	Stream Origin	Confinmt.	Gradt. %		Channel		Habitat		Types		Stream
No.	Name	To Stream	1/4 Section	1st Reach	1st Reach	FP2/3	LC	MM	MC	MV	SV	VH	Total
138		MAIN	T1NR9WS21SE	CH	14							3000	3000
139		MAIN	T1NR9WS21NE	CH	10						1000	4000	5000
140		139	T1NR9WS21NE	CH	23							2800	2800
141		MAIN	T1NR9WS21NE	CH	18							2500	2500
142	Sharp	MAIN	T1NR9WS21NE	CH	9						1600	4000	5600
143		MAIN	T1NR9WS16SW	CH	11						2800	1500	4300
144	Pipe	MAIN	T1NR9WS16SW	CH	14						600	3600	4200
145		MAIN	T1NR9WS16NW	CH	11						2200	2500	4700
146		MAIN	T1NR9WS16NW	CH	40							2200	2200
147	Slide	MAIN	T1NR9WS9SW	CH	15						3000	1000	4000
148	Tilden	MAIN	T1NR9WS9NW	CH	7						4000	3000	7000
149		148	T1NR9WS9NW	CH	20							4500	4500
150		148	T1NR9WS5SE	CH	26							4200	4200
151		MAIN	T1NR9WS4SE	CH	11						800	4000	4800
152		151	T1NR9WS4SE	CH	22							2800	2800
153	Blue Star	MAIN	T1NR9WS4SE	CH	9						1500	7600	9100
154		MAIN	T1NR9WS3SW	CH	16						1800	4000	5800
155		MAIN	T1NR9WS3SW	CH	12						2500	2500	5000
156		MAIN	T1NR9WS3SW	CH	27							3500	3500
157		MAIN	T1NR9WS3SE	CH	17						800	3000	3800
158	Whitney	MAIN	T1NR9WS3SE	CH	13						2000	5200	7200
159		MAIN	T1NR9WS3NE	CH	23						1500	1300	2800
160		MAIN	T1NR9WS3NE	CH	23						800	1600	2400
161		MAIN	T1NR9WS3NE	CH	7						3200	200	3400

Stream	Stream	Tributary	Stream Origin	Confinmt.	Gradt. %		Channel		Habitat		Types		Stream
No.	Name	To Stream	1/4 Section	1st Reach	1st Reach	FP2/3	LC	MM	MC	MV	SV	VH	Total
162	Company	SFK	T1NR9WS2NE	CH	8				6000		1500	4000	11500
163		SFK	T1NR9WS1NE	CH	23							3500	3500
164		SFK	T1NR8WS6SE	CH	20							3700	3700
165		SFK	T1NR8WS6SE	CH	14						1600	3000	4600
166	Mutt	SFK	T1NR8WS7NE	CH	8						3000	6400	9400
167		SFK	T1NR8WS8NW	CH	7						1800	2800	4600
168		SFK	T1NR8WS8NW	CH	40							3000	3000
169	Fitch	SFK	T1NR8WS8SE	CH	6						4800	3600	8400
170		169	T1NR8WS8SE	CH	23						5800	1800	7600
171		169	T1NR8WS8SE	CH	9							4000	4000
172		SFK	T1NR8WS9NW	CH	20						800	2800	3600
173		SFK	T1NR8WS9NE	CH	18						1200	2000	3200
174		NFK	T2NR9WS35SW	CH	40							2800	2800
175		NFK	T2NR9WS35NW	CH	7						3800	5000	8800
176		NFK	T2NR9WS35NW	CH	40							1500	1500
177		NFK	T2NR9WS26SE	CH	16							3200	3200
178		NFK	T2NR9WS25SW	CH	24							3000	3000
179		NFK	T2NR9WS25SW	CH	16							3800	3800
180		NFK	T2NR9WS25SE	CH	16				1000			6500	7500
181	Schroeder	NFK	T2NR8WS31NW	CA	3				6500		9200	26800	42500
181A	French	SCHROEDER	T2NR8WS29NW	CA	3						5600	15000	20600
182		NFK	T2NR8WS31NW	CH	27							2800	2800
183	Shaw	NFK	T2NR8WS30SE	CH	23						1400	3800	5200
184		NFK	T2NR8WS32NE	CH	23							4000	4000
185	Fossil	NFK	T2NR8WS32NE	CH	11					1500		3800	5300

Stream	Stream	Tributary	Stream Origin	Confinmt.	Gradt. %		Channel		Habitat		Types		Stream
No.	Name	To Stream	1/4 Section	1st Reach	1st Reach	FP2/3	LC	MM	MC	MV	SV	VH	Total
186		185	T2NR8WS32SE	CH	11							2200	2200
187		NFK	T2NR8WS33NW	CH	20							2500	2500
188	Triangulation	NFK	T2NR8WS28SW	CH	7					1500	3800	12000	17300
189	Fick	NFK	T2NR8WS33NE	CH	6					1800	1500	2500	5800
190	Western	NFK	T2NR8WS34SW	CH	13						2400	2000	4400
191		NFK	T2NR8WS34SW	CH	6						1000	1800	2800
192		NFK	T1NR8WS3NE	CH	16							2200	2200

CHTs: FP2 floodplain large/medium; FP3 floodplain ssmall stream; LC low gradient constrained; MM moderate terrace/hillslope confined; MC moderate gradient constrained; MV moderately steep, narrow valley; SV steep headwater; VH very steep headwater.

APPENDIX B. THREATENED AND ENDANGERED PLANT AND ANIMAL SPECIES IN TILLAMOOK COUNTY.

Group

Scientific Name Common Name	TNC Rank	FED Status	ODFW Status	ONHP List

FISH

Acipenser medirostris green sturgeon	S4	SoC	—	3

Habitat: over soft bottoms in ocean and estuaries, deep pools in large rivers. Spawn in large rivers during the spring.

Lampetra ayresi river lamprey	S4	SoC	—	4

Habitat: close to shore, large inland streams. Parasitic on ocean fish for 1–2 years , then ascends streams in late spring and early summer to spawn in gravel before dying. Young live in streams 5– 6 years before migrating to ocean.

Lampetra tridentata Pacific lamprey	S4	SoC	SV	3

Habitat: same as river lamprey.

Oncorhynchus clarki clarki coastal cutthroat	S3	—	—	3

Habitat: small headwater tributaries (first and second order streams), migrate form June to October. Fry use stream edges and backwater pools.

Oncorhynchus keta chum salmon	S4	—	SC	2

Habitat: lower mainstem and tributaries, migrate from November to December. Fry move directly into estuaries.

Oncorhynchus kisutch	S3	PT	SC	1

coho salmon

Habitat: small tributaries, migrate from September to January. Fry use backwater pools and stream edges, remain in streams one year.

AMPHIBIANS

Aneides ferreus	S4	—	SU	3

clouded salamander

Habitat: forest dweller in moist areas under downed logs and forest debris. Often in clearings caused by fire or timber harvest if logs are present.

Ascalpus truei	S3	SoC	SV	3

tailed frog

Habitat: cold, fast-flowing permanent streams, normally in forests and occasionally in streams through non-forested areas. Impacted by loss of riparian and sedimentation.

Bufo boreas	S4	—	SV	3

western toad

Habitat: very wide range of habitats, probably throughout county. Only requirement is source of water for breeding.

Rana aurora aurora	S4	SoC	SU	3

northern red-legged frog

Habitat: occurs in meadows, woodlands and forests. Usually found near ponds, marshes and streams where there is dense vegetative cover within 300 yards of a stream.

Rhyacotriton kezeri	S3	—	SC	3

Columbia seep salamander

Habitat: found in rocks bathed by a constant flow of cold water, also occuring in cold rocky streams, lakes and seeps. Usually remains in splash zone of streams and spray zone of waterfalls in alder or conifer forest.

Rhyacotriton variegatus	S3	SoC	SC	3

southern seep salamander

Habitat: same as Columbia seep salamander.

REPTILES

Clemmys marmorata marmorata	S2	SoC	SC	2

northwestern pond turtle

Habitat: quiet water in small lakes, marshes and sluggish streams. Eggs laid in terrestrial nests within several hundred yards of water.

Contia tenuis	S3	—	SV	4

sharptail snake

Habitat: found in moist areas of coniferous forest, deciduous woodlands, chaparral and grasslands away from coast in north state. Frequents open, grassy areas at forest edges and seeks cover under logs, rocks, fallen branches and talus.

BIRDS

Brachyramphus marmoratus	S2	LT	LT	1

marbled murrelet

Habitat: nests in large trees in older forests within 50 miles of the coast. Forages in the marine environment within two kilometers of the coast.

Branta canadensis leucopareia	S2N	LT	LE	1

Aleutian Canada goose

Habitat: feed in both marsh and upland habitats including meadow, pasture, and agricultural lands. Breed in a variety of habitats near water including shores of rivers, lakes and reservoirs.

Branta canadensis occidentalis	S2N	—	—	4

dusky Canada goose

Habitat: same as Aleutian Canada goose.

Charadrius alexandrinus nivosus	S2	LT	Lt	1

western snowy plover

Habitat: along the coast, nests on sand spits near river outlets and on level, sandy beaches.

Elanus leucurus	S1B,S3N	—	—	3

white-tailed kite

Habitat: lower elevation grasslands, agricultural areas, meadows, oak and riparian woodlands, marshes and wetlands.

Falco peregrinus anatum	S1B	LE	LE	1

American peregrine falcon

Habitat: nests in cliffs overlooking large open areas with an ample food supply. Nest along seacoast, near marshes and even in cities, but not in forest interiors.

Histrionicus histrionicus	S2B,S2N	SoC	SU	2

harlequin duck

Habitat: breeds along low-gradient, slower flowing reaches of mountain streams in forested areas. Uses swift waters and rapids during non-breeding seasons.

Oceanodroma furcata	S2	—	SV	2

fork-tailed storm-petrel

Habitat: hunts prey over the open ocean. Nests on offshore islands that have some soil development.

Pelecanus occidentalis	S2N	LE	LE	2

brown pelican

Habitat: feeds on fish in estuaries and the open ocean. Nests on predator-free pocks along the coast.

Progne subis	S3B	—	SC	3

purple martin

Habitat: need nesting habitat (holes in trees, ledges) in close proximity to open areas for foraging. Often near the shores of lakes and rivers, unsalvaged forestlnads killed by fire, and near large meadows.

Strix occidentalis caurina	S3	LT	LT	1

northern spotted owl

Habitat: breeds only in late-successional mixed conifer forest. Prefers large forest stands (over 12,000 acres) with multiple layers and an open canopy.

MAMMALS

Arborimus albipes	S3	SoC	SU	3

white-footed vole

Habitat: riparian areas (particularly alder) in coniferous forest in proximity to small clearings supporting forbs.

Eumetopias jubatus	S2	LT	SV	3

northern sea lion

Gulo gulo luteus	S2	SoC	LT	2

California wolverine

Habitat: open forests at higher elevations. Crosses clearcuts, but avoids young, dense regenerating forests and brushy areas.

Martes americana	S3	—	SV	3

American marten

Habitat: forested habitat at any elevation. Prefer mature forest with closed canopy, not found in dry woodlnads.

Martes pennanti pacifica	S2	SoC	SC	2

Pacific fisher

Habitat: mature, closed canopy coniferous forest with deciduous component along riparian corridors.

Myotis thysanodes	S3	SoC	SV	3

fringed bat

Habitat: prefers forested or riparian areas. Forages by picking up food items (beetles, moths, crickets) from shrubs or the ground.

Plecotus townsendii townsendii	S3	SoC	SC	2

Pacific western big-eared bat

Habitat: Found around suitable roost sites (buildings, caves, mines, and bridges). Very intolerant of human disturbance of winter hibernating sites and summer roosts.

GASTROPODA - SNAILS AND SLUGS

Megomphix hemphilli Oregon megomphix (snail)	S2	—	—	1

HEMIPTERA - TRUE BUGS

Mesovilia mulsanti Mulsant's small water strider	S?	—	—	3
Nabicula propinquua marsh nabid (bug)	S?	—	—	3
Bembidion tigrinum cryptic beach carabid beetle	S3	—	—	3
Cicindela hirticollis siuslawensis Siuslaw sand tiger beetle	SH	—	—	3

LEPIDOPTERA - BUTTERFLIES AND MOTHS

Speyeria zerene hippolyta Oregon silverspot butterfly	S1	LT	—	1

VASCULAR PLANTS

Abronia latifolia	S3	—	—	3
yellow sandverbena				
Sandy sea beaches and dunes.				
Carex brevicaulis	SU	—	—	3
short stemmed sedge				
Dry, grassy slopesand coastal bluffs, and in open, rocky forest at low elevations.				
Carex macrocephala	S3	—	—	3
bighead sedge				
Sandy seashores and coastal dunes.				
Castilleja ambigua	SU	—	—	3
johnny-nip				
Cordylanthus maritimus pallustris	S1	SoC	LE	1
salt marsh bird's-beak				
Upper edge of salt marshes.				
Darlingtonia californica	S4	—	—	4
California pitcher plant				
Seeps and bogs over a broad elevational range.				
Dodecatheon austrofrigidum	S2	SoC	—	1
frigid shootingstar				
Wet meadows.				
Eleocharis parvula parvula	SU	—	—	3
small spikerush				
Very small mat forming in salt marshes and brackish tidal flats.				

Erigeron peregrinus peregrinus wandering daisy	S2	—	—	2

Moist to wet meadows, streamsides and open forests from middle to high elevations.

Eriophorum chamissonis russet cotton-grass	S1	—	—	2

Fens, bogs, wet ditches at low to middle elevations.

Erythronium elegans Coast Range fawn lily	S1	SoC	LT	1

Moist open areas.

Erythronium revolutum coast fawn lily	S4	—	—	4

Open to moderately dense moist woodlands, riverside areas, meadows at low elevations.

Filipendula occidentalis queen-of -the-forest	S2	SoC	C	1
Honkenya peploides sea-beach sandwort	SU	—	—	3

Sandy, gravelly or rocky ocean beaches.

Lewisia columbiana rupicola rosy lewisia	S2	—	—	2

Exposed gravelly or rocky ridges, slopes and outcrops at middle to high elevations.

Najas guadalupensis common water-nymph	SU	—	—	3
Poa laxiflora loose-flowered bluegrass	S3	—	—	4

Moist, shady forest glades, edges and rocky slopes at low elevations.

Poa marcida	S4	—	—	4
weak bluegrass				
Poa unilateralis	S1	—	—	3
San Francisco bluegrass				
Puccinellia pumila	SU	—	—	3
dwarf alkaligrass				
Sea beaches and tidal marshes.				
Rhinanthus crista-galli	S4	—	—	4
yellow rattle				
Meadows, fields, open grassy sites, beaches, roadsides at low to middle elevations.				
Saxifraga hitchcockiana	S1	SoC	C	1
Saddle Mt. saxifrage				
Senecio flettii	S2	—	—	2
Flett's groundsel				
Sidalcea hendersonii	S1	—	—	2
Henderson's sidalcea				
Wet meadows, tidal marshes, and flats at low elevations.				
Sidalcea hirtipes	S2	—	C	1
bristly-stemmed sidalcea				
Sidalcea nelsoniana	S2	LT	LT	1
Nelson's sidalcea				
Silene douglasii oraria	S1	SoC	LT	1
Cascade Head catchfly				
Dry, open slopes and grassy areas at low to middle elevations.				

Synthyris schizantha	S4	—	—	4
fringed synthyris				

Open coniferous forest, glades and forest edges at low elevations.

Triglochin striata	SU	—	—	3
three-ribbed arrow-grass				
Vaccinium oxycoccos	S4	—	—	4
wild bog cranberry				

Sphagnum hummocks of bogs at low to middle elevations, wet subalpine meadows.

MOSSES AND LIVERWORTS

Calypogeia sphagnicola	S2	—	—	2
liverwort				
Lophozia laxa	S2	—	—	2
liverwort				
Metzgeria temperata	S1	—	—	3
liverwort				
Pohlia sphagnicola	S2	—	—	2
moss				

LICHENS

Bryoria bicolor	S2	—	—	2
lichen				
Hypogymnia duplicata	S2	—	—	3
lichen				

On trees and shrubs, especially conifers, in open usually coastal localities at low elevations.

Teloschistes flavicans	S2	—	—	3
lichen				

Usnea hesperiana lichen	S1	—	—	2
Usnea rubicunda lichen	S2	—	—	3

TNC Rank—the G rank is for global occurrence of the species, the T rank is for a subspecies or race, and the S rank is for within the state of Oregon. 1 is critically imperiled due to extreme rarity or vulnerability; 2 is imperiled because of rarity or very vulnerable to extinction; 3 is rare, uncommon or threatened; 4 is not rare and apparently secure; and 5 is demonstrably widespread, abundant and secure.

FED Status—endangered are in danger of becoming extinct within the foreseeable future, while threatened are likely to become endangered in the forseeable future. LE is listed endangered, LT is listed threatened, PE is prop[osed endangered, PT is proposed threatened, C is a proposed candidate for listing, and SoC is a species of concern that is at a lower status than a candidate.

ODFW Status—SC is critical, listing as threatened or endangered is pending or will be a candidate if immediate conservation actions are not taken; SV is vulnerable, listing is not imminent and can be avoided through adequate protective measures and monitoring; SP is peripheral or naturally rare, these species are on the edge of their range in Oregon; and SU is undetermined status, for these species the status is unclear and may be subject to decline.

ONHP List—List 1 contains species that are threatened with extinction throughout their entire range; List 2 contains species that are threatened with localized extinction int he state of Oregon; List 3 contains speceis which require more information before their status can be determined, but which may be threatened or endangereed in Oregon; List 4 contains species that are of conservation concern in Oregon.

APPENDIX C. WILDLIFE SPECIES OF THE KILCHIS AREA

✓ - indicates species is threatened or endangered

Common Name	Scientific Name	Seasonal	Habitat	Abundance
Amphibians				
Pacific Giant Salamander	*Dicamptodon tenebrosus (Dicamptodon ensatus)*		Damp forests with downed logs near clear cold streams and rocky shores of mountain lakes, larvae occupy cold clear streams	
Northwestern Salamander	*Ambystoma gracile*		Open grassland, woodland, or dense forest under rocks, boards, and logs near ponds, lakes, and slow streams	
Long-toed Salamander	*Ambystoma macrodactylum*		Wide variety including semiarid sagebrush, dry woodlands, humid forests, and alpine meadows. Lives under bark and rocks near ponds, lakes and streams	
Columbia Torrent (Seep) Salamander (Previously Olympic Salamander)	*Rhyacotrion kezeri (Thyacotriton olympicus)*		Near rocks that are constantly wet from cold water streams usually within coniferous forests or alder forests	✓
Ensatina	*Ensatina eshscholtzi*		Deciduous and evergreen forests under rocks and rotting logs in moist environment, but not associated with open water	
Western Red-backed Salamander	*Plethodon vehiculum*		Under rocks, logs, bark, and boards in damp locations in humid forests	
Dunn's Salamander	*Plethodon dunni*		Moss covered rock rubble of seepages and under rocks and logs near permanent water.	
Clouded Salamander	*Aneides ferreus*		Forests of douglas fir, cedar, alder and redwood often at borders of clearings in moist areas	✓
Roughskin Newt	*Taricha granulosa*		Grassland, woodland, and forest with ponds, lakes, or streams for breeding	
Tailed Frog (Rare)	*Ascaphus truei*		Clear cold rocky permanent streams in humid forests of douglas fir, pine, spruce, redwood, maple, alder and bay.	✓

Common Name	Scientific Name	Seasonal	Habitat	Abundance
			Local populations going extinct due to timber harvesting and habitat fragmentation.	
Western Toad	*Bufo boreas*		Deserts, chaparral, grasslands, woodlands, and forests provided some source of water available for breeding	✓
Pacific Chorus Frog (formerly Pacific Treefrog)	*Pseudacris regallia (Hyla regilla)*		Frequents a variety of habitats such as sagebrush deserts and grasslands to forests, from sea level high into the mountains. Can wander far from water	
Red-legged Frog	*Rana aurora*		Marshes, slow parts of streams, lakes, reservoirs, ponds, favoring dense jground cover and aquatic or overhanging vegetation	✓
Bullfrog	*Rana catesbeiana*		Highly aquatic, remaining in or near permanent water such as sloughs, irrigation ditches, marshes, ponds, rivers, but rare or absent from cold high mountain streams	
Reptiles				
Western Pond Turtle	*Clemmys marmorata*		Prefers quiet water in small lakes, marshes, sluggish streams with muddy or rocky bottoms. Requires logs, rocks, or mudbanks to bask on.	✓
Northern Alligator Lizard	*Elgaria coerulea (A.K.A. Gerrhonotus coeruleus)*		Meadow edges in coniferous forests and in riparian zones.	
Western Skink	*Eumeces skiltonianus*		Moist places under rocks or logs in a variety of habitats from grasslands and desert scrub to juniper woodlands and coniferous forests.	
Rubber Boa	*Charina bottae*		Grassland, woodland, and forest, especially in clearings with rotting stumps and logs.	
Western Terrestrial Garter Snake	*Thamnophis elegans*		Usually near moist areas but can be found far from water.	
Common Garter Snake	*Thamnophis sirtalis*		Ponds, marshes, prairie swales, roadside ditches, streams, sloughs moist coniferous forests, damp	

Common Name	Scientific Name	Seasonal	Habitat	Abundance
			meadows, farms, and city lots	
Northwestern Garter Snake	*Thamnophis ordinoides*		Meadows and clearings in forested areas where there is abundant low-growing vegetation, also in urban areas	
Mammals				
Virginia Opossum	*Didelphis virginiana (Didelphis marsupialis)*		Farming areas, woodlands, and along streams, marshes, riparian areas	
Vagrant Shrew	*Sorex vagrans*		Marshes, bogs, wet meadows, also along streams in forests	
Montane Shrew a.k.a. Dusky Shrew (previously Vagrant Shrew)	*Sorex monticolus (Sorex obscurus)*		Cool moist areas within coniferous forests, damp meadows, mossy banks of streams, sphagnum bogs, and marshes. Usually under downed logs.	
Baird's Shrew (previously Vagrant Shrew)	*Sorex bairdi*		*Endemic to northwest oregon.* Cool moist areas within coniferous forests, damp meadows, mossy banks of streams, sphagnum bogs, and marshes. Usually under downed logs.	
Trowbridge Shrew	*Sorex trowbridgii*		Deciduous and coniferous forests in the dry areas several meters from streams	
Pacific Water (or Marsh) Shrew	*Sorex bendirii*		Moist forests, swamps, marshes, and beach debris,	
Shrew-mole	*Neurotrichus gibbsii*		Moist areas in shady ravines and along streams in with thick vegetation cover, from sea-level to 8000 ft.	
Townsend's Mole	*Scapanus townsendii*		Moist areas where soil is easily worked - fields, pastures, grasslands, gardens, and coniferous forests	
Coast (or Pacific) Mole	*Scapanus orarius*		Well-drained soils in meadows, deciduous riparian woodland, sagebrush scrub and coniferous forests	
Little Brown Myotis	*Myotis lucifugus*		Closely associated with water. Moist forests, riparian woodlands	
Fringed Myotis	*Myotis thysanodes*		Forested and riparian areas. Nursery colonies in caves and attics of old buildings	✓

Common Name	Scientific Name	Seasonal	Habitat	Abundance
Long-eared Myotis	*Myotis evotis*		Thinly forested and edges of forests, around building or occasionally caves	
California Myotis	*Myotis californicus*		Mine tunnels, hollow trees, loose rocks, buildings, bridges; it is chiefly a crevice dweller. Often forages near or over open water.	
Yuma Myotis	*Myotis yumanensis*		Caves, tunnels, or buildings closely associated with water. Riparian , moist woodlands, and open forests.	
Long Legged Myotis	*Myotis volans*		Buildings, small pockets and crevices in rock ledges	
Western Red Bat	*Lasiurus blossevillii*		Wooded areas; it normally roosts in trees, occasionally enters caves	
Big Brown Bat a.k.a. House Bat	*Eptesicus fuscus*		Caves, tunnels, crevices, hollow trees, buildings, deciduous wooded areas. Forages over open areas.	
Hoary Bat	*Lasiurus cinereus*		Wooded areas. Forages along riparian corridors.	
Townsend's (or Western) Big-eared Bat	*Plecotus townsendi*		Caves, bridges, mine tunnels, and buildings for roosts. Intolerant of human disturbance. *Listed in area on early accounts, not later ones.*	✓
Silver-haired Bat	*Lasionycteris noctivagans*		Forested areas, especially older douglas fir/western hemlock forests. Forages over ponds and streams in woods.	
Snowshoe Hare	*Lepus americanus*		Swamps, coniferous forests, salal thickets, and riparian vegetation	
Brush Rabbit	*Sylvilagus bachmani*		Chaparral or thick brush, edges of meadows.	
Mountain Beaver	*Aplodontia rufa*		Forests and dense thickets near streams, especially early successional forests	
California Ground Squirrel	*Spermophilis beechyi (Citellus becheyi)*		Pastures, grainfields, slopes with scattered trees, rocky ridges; avoid thick chaparral and dense woods.	
Townsend's Chipmunk	*Tamias townsendii (Eutamicas townsendii)*		Coniferous forests and adjacent chaparral	
Western Gray Squirrel	*Sciurus griseus*		Deciduous or broadleaf evergreen woodlands dominated by oaks. Also mixed forests of tanoak, madrone, or	

Common Name	Scientific Name	Seasonal	Habitat	Abundance
			douglas-fir.	
Douglas' Squirrel (Chickaree)	*Tamiasciurus douglasii*		Coniferous forests or wooded suburbs	
Northern Flying Squirrel	*Glaucomys sabrinus*		Forests of douglas-fir, redwood, and other conifers. Prefer tall trees. Forages along streams and forest-meadow transitions.	
Western Pocket Gopher	*Thomomys mazama*		Open, grassy meadows and wet pastures found in forests.	
American Beaver	*Castor canadensis*		Streams and lakes with trees or alders on banks	
Deer Mouse	*Peromyscus maniculatus*		Nearly every dry-land habitat within its range is occupied somewhere by this species	
Bushy-tailed Woodrat	*Neotoma cinerea*		High mountains, rimrock, rockslides, pines	
Western (California) Redback Vole	*Clethrionomys occidentalis*		Forest floors, moist and strewn with logs. Uses small clearings created by fallen trees.	
White-footed Vole (Pacific Phenacomys) (Rare)	*Phenacomys albipes*		Dense forests, near small streams	✓
Red Tree Vole (Tree Phenacomys)	*Phenacomys longicaudus*		Douglas-fir, spruce, hemlock and fir stands	
Townsend Vole	*Microtus townsendi*		Moist field, sedges, tules, meadows, from tidewater to alpine meadow; usually near water	
Long-tailed Vole	*Microtus longicaudus*		Streambanks and mountain meadows, occasionally in dry situations, brushy areas in winter	
Oregon Vole	*Mirotus oregoni*		Forests, brush, grassy areas; usually on dry slopes	
Muskrat	*Ondatra zibethicus*		Marshes, edges of ponds, lakes and streams; cattails, rushes, water lilies, open water	
Norway Rat	*Rattus norvegicus*		Near human activity such as garbage dumps, barns, food stoarge or processing facilities, buildings, and	

Common Name	**Scientific Name**	**Seasonal**	**Habitat**	**Abundance**
			gardens	
House Mouse	*Mus musculus*		Towns, buildings, farms, croplands, grain fields, abandoned pastures, fence rows.	
Pacific Jumping Mouse	*Zapus trinotatus*		Wet, marshy areas, open meadows, woods	
Porcupine	*Erethizon dorsatum*		Usually forested areas but occasionally away from trees if brush is available	
Nutria (or Coypu)	*Myocastor coypus*		Found along streams, lakes, marshes, irrigation ditches	
Coyote	*Canis latrans*		Prairies, open woodlands, brushy or boulder-strewn areas, clear cuts and logging roads promote movement into areas	
Red Fox	*Vulpes vulpes*		Open habitats such as meadows and grasslands with brush or open forests	
Gray Fox	*Urocyon cinereoargenteus*		Open forests to dense forests	
Black Bear	*Ursus americanus*		Mixed deciduous-coniferous forests with dense understories but also in clear-cuts. Generally mountainous areas	
Raccoon	*Procyon lotor*		Along streams and lake borders where there are wooded areas or rock cliffs nearby, also seashore areas.	
Marten	*Martes americana*		Fir, spruce, and hemlock forests with closed canopies preferred. Structure of forest more important than type of forest.	
Fisher	*Martes pennanti*		Extensive mixed hardwood forests with closed canopies, riparian corridors. *Presence listed in earlier accounts but not recently.*	
Ermine (or Short-tailed Weasel)	*Mustela erminea*		Brushy or edges of wooded areas, usually not far from water	
Long-tailed Weasel	*Mustela frenata*		Not restricted, it is found in all land habitats.	
Mink	*Mustela vison*		Along streams, marshes and lakes. Absent from forest interiors.	

Common Name	Scientific Name	Seasonal	Habitat	Abundance
Western Spotted Skunk	*Spilogale gracilis (sometimes putorius)*		Coniferous forests, brushy or sparsely wooded areas, along streams, among boulders, prairies	
Striped Skunk	*Mephitis mephitis*		Semi-open country, mixed woods, brushland, and open prairie preferred, usually within 2 miles of water.	
Northern River Otter	*Lutra canadensis*		Along streams, lakes, swamps, marshes, and the seashore	
Mountain Lion	*Felis concolor*		Dense forests to open woodlands and canyons.	
Bobcat	*Lynx rufus*		Dense forests, thickets, clear-cuts.	
Elk	*Cervus canadensis*		Semi-open forest, mountain meadows in summer, foothills, plains, and valleys	
Mule Deer or Blacktail Deer	*Odocoileus hemionus columbianus*		Edges of forests and chapparal thickets, not dense forests. Prefer early successional stage areas.	

Birds				
	Breeds in area	✸		
	May breed in area	_		
	Migrant; seen only in transit	**m**		
	Resident; found all year	**r**	**Common**	**c**
	Summer visitor	**sv**	**Rare**	**r**
	Summer resident	**sr**	**Uncommon**	**u**
	Winter visitor	**wv**		
Common Loon	*Gavia immer*	r	Ocean, estuary, lakes	c
Arctic Loon	*Gavia arctica*	m	Estuary, ocean	u
Red-throated Loon (1)	*Gavia stellata*	m	Estuary, ocean	u
Western Grebe (1)	*Aechmophorous occidentalis*	-wv	Lakes, estuary	c
Red-necked Grebe	*Podiceps grisegena*	-wv	Lakes, rivers, estuary	u
Horned Grebe	*Podiceps auritus*	-wv	Lakes, rivers, estuary	c
Eared Grebe	*Podiceps caspicus*	-wv	Lakes, marshes, rivers	u
Pied-billed Grebe	*Podilymbus podiceps*	r	Rivers, marshes, estuary	u
Black-footed	*Diomedea nigripes*	r	Ocean	c

Albatross				
Laysan Albatross	*Diomedea immatabilis*	wv	Ocean	r
Fulmar	*Fulmarus glacialis*	wv	Ocean	c
Sooty Shearwater	*Puffinus griseus*	m	Ocean	c
Slender-billed Shearwater	*Puffinus tenuirostris*	m	Ocean	u
Pink-footed Shearwater	*Puffinus creatopus*	m	Ocean	u
Pale-footed Shearwater	*Puffinus carneipes*	m	Ocean	u
New Zealand Shearwater	*Puffinus bulleri*	m	Ocean	r
Leach's Storm Petrel	*Oceanodroma leucorhoa*	*r	Ocean, offshore rocks	c
Fork-tailed Storm Petrel (1)	*Oceanodroma furcata*	r*	Ocean, offshore rocks	c ✓
White Pelican (1)	*Pelecanus erythrorhynchos*	wv	Lakes, marshes, salt bays, beaches	c
Brown Pelican (1) (3)	*Pelecanus occidentalis*	wv	Ocean, estuary	c
Double-crested Cormorant (1)	*Phalacrocorax auritus*	r*	Ocean, lakes, estuary	c
Brandt's Cormorant*	*Phalacrocorax penicillatus*	r*	Ocean, offshore rocks, estuary	c
Pelagic Cormorant*	*Phalacrocorax pelagicus*	r*	Ocean, offshore rocks, estuary	c
American Bittern*	*Botaurus lentiginosus*	sr*	Marshes	u
Black-crowned Night Heron* (1)	*Nycticorax nycticorax*	r*	Marshes, estuary	u
Green Heron*	*Butorides virescens*	sr*	Marshes, lakes, rivers	u
Snowy Egret	*Leucophoyx thula*	sr	Marshes, lakes, estuary	r
Great Egret	*Casmerodius alba*	wv		
Common Egret	*Casmerodius albus*	r	Marshes, lakes	r
Great Blue Heron* (1)	*Ardea herodias*	r*	Estuary, lakes, steams, marshes	c
Tundra Swan	*Cygnus columbianus*	wv	Lakes, rivers, marshes	r
Trumpter Swan	*Cygnus buccinator*	wv		
White-fronted Goose	*Anser albifrons*	wv	Lakes, estuary	r
Snow Goose	*Chen caerulescens*	wv	Tundra (summer), marshes, grain fields,	u

			prairies, ponds, bays	
Ross' Goose	*Chen rossii*	wv		
Emperor Goose	*Chen canagica*	wv		
Canada Goose	*Branta canadensis*	wv⁻	Lakes, rivers, fields, marshes	r
Brant	*Branta nigricans*	wv	Estuary, open ocean	c
Mallard*	*Anas platyrhynchos*	r*	Lakes, rivers, estuary, fields	
Gadwall	*Anas strepera*	r⁻	Marshes, lakes	u
Green-winged Teal	*Anas carolinensis*	r⁻	Marshes, estuary	c
American Wigeon	*Anas americana*	wv⁻	Marshes, lakes, fields	c
Eurasian Widgeon	*Anas penelope*	wv	Marshes, lakes, fields	u
Pintail	*Anas acuta*	r⁻	Lakes, ponds	c
Shoveler	*Anas clypeata*	wv⁻	Marshes, lakes, estuary	u
Blue-winged Teal*	*Anas discors*	r*	Marshes, estuary	u
Cinnamon Teal*	*Anas cyanoptera*	sr*	Marshes, estuary	u
Ruddy Duck*	*Oxyura jamaicensis*	r⁻	Lakes, marshes, estuary	c
Wood Duck*	*Aix sponsa*	r*	Lakes, streams	c
Canvasback*	*Aythya valisineria*	wv⁻	Marshes, estuary, lakes	c
Redhead*	*Aythya americana*	wv⁻	Estuary, ponds, lakes	r
Ring-necked Duck*(4)	*Aythya collaris*	wv⁻	Lakes, ponds	r
Tufted Duck	*Aythya fuligula*	wv	Lakes, ponds	r
Greater Scaup	*Aythya marila*	wv	Lakes, estuary	c
Lesser Scaup* (4)	*Aythya affinis*	wv⁻	Lakes, estuary	c
Sandhill Crane	*Grus canadensis*	r	Prairies, grain fields, marshes, summer mountain meadows, tundra	u
King Eider	*Somateria spectabliis*	wv	Coasts, ocean †	u
Black Scoter	*Melanitta nigra*	r	Ocean, lakes, estuary	u
White-winged Scoter	*Melanitta fusca*	r	Ocean, lakes, estuary	c
Surf Scoter	*Melanitta perspicillata*	r	Ocean, lakes, estuary	c
Harlequin Duck*	*Historionicus historinicus*	wv⁻	Ocean, estuary	
Old Squaw	*Clangula hyemalis*	wv	Ocean, lakes, estuary	o
Barrows Goldeneye* (4)	*Bucephala islandica*	wv⁻	Lakes	r
Common Goldeneye	*Bucephala clangula*	wv	Lakes, ponds, rivers	c
Bufflehead (4)	*Bucephala albeola*	wv	Lakes, estuary	c
Common	*Mergus merganser*	r*	Steams, lakes, estuary	u

Merganser*				
Red-breasted Merganser	*Mergus serrator*	wv	Rivers, estuary	u
Hooded Merganser*	*Lophodytes cucullatus*	r*	Lakes, streams	u
Virginia Rail*	*Rallus limicola*	r⁻	Marshes	u
Sora*	*Porzana carolina*	sr⁻	Marshes	u
American Coot*	*Fulica americana*	r*	Lakes, estuary, marshes, fields	c
Black Oystercatcher*	*Haematopus bachmani*	r*	Rocky coasts	u
American Avocet	*Recurvirostra americana*	wv	Marshes, mudflats, alkaline lakes, ponds, coastal bays	c
Snowy Plover (1)(3)	*Charadrius alexandrinus*	r⁻	Sandy beaches, dunes	u
Semipalmated Plover	*Charadrius semipalmatus*	m	Shores, tideflats	u
Killdeer*	*Charadrius vociferus*	r*	Field, tideflats	c
Black-bellied Plover	*Pluvialis squatarola*	m	Mudflats, open marshes	
Lesser Golden Plover	*Pluvialis doninica*	m	Mudflats, shores	r
Marbled Godwit	*Limosa fedoa*	m	Beaches, mudflats	u
Whimbrel	*Numenius phaeopus*	m	Mudflats, open marshes	u
Long-Billed Curlew (3)	*Numenius americanus*	m	Marshes	u
Willet	*Catoptrophorus semipalmatus*	m	Marshes, beaches	u
Greater Yellowlegs	*Tringa melanoleuca*	m	Marshes, mudflats	u
Lesser Yellowlegs	*Tringa flavipes*	m	Marshes, mudflats	r
Solitary Sandpiper	*Tringa solitaria*	m	Streams, marshes	r
Spotted Sandpiper*	*Actitis macularia*	r*	Streams, marshes	u
Wandering Tattler	*Heteroscelus incanus*	m	Rocky coasts	u
Wilson's Phalarope*	*Phalaropus tricolor*	m*	Marshes	r
Red-necked Phalarope	*Phalaropes lobatus*	m	Ocean	c
Red Phalarope	*Phalaropus fulicaria*	m	Ocean	c
Short-billed Dowitcher	*Limnodromus griseus*	m	Mudflats	c
Long-billed Dowitcher	*Limnodromus scolopaceus*	m	Mudlflats	c
Stilt Sandpiper	*Caladris himantopus*	wv	Shallow pools, ponds	u
Common Snipe	*Gallinago gallinago*	r⁻	Marshes, wet meadows	u

Surfbird	*Aphriza virgata*	m	Rocky coasts, jetties	c
Ruddy Turnstone	*Arenaria interpres*	m	Rocky shores	u
Black Turnstone	*Arenaria melanocephala*	m	Rocky coasts	c
Rock Sandpiper	*Calidris ptilocnemis*	w	Rocky shores	u
Dunlin	*Calidris alpina*	wv	Beaches, tidal flats	c
Red Knot	*Calidris canutus*	m	Marshes, mudflats	r
Sanderling	*Calidris alba*	m	Sandy beaches	c
Semipalmated Sandpiper	*Calidris pusillus*	m	Beaches, judflats	r
Western Sandpiper	*Calidris mauri*	m	Mudflats, beaches	c
Least Sandpiper	*Calidris minutilla*	wv	Marshes, tidal areas	u
Baird's Sandpiper	*Calidris bairdii*	m	Mudflats	r
Sharp-tailed Sandpiper	*Calidris acuminata*	wv	Grassy borders of salt marsh	u
Pectoral Sandpiper	*Calidris melanotos*	m	Marshes, mudflats	r
Buff-breasted Sandpiper	*Tryngites subrufilollis*	w	Short grass, prairie fields	u
South Polar Skua	*Catharacta maccormicki*	m	Open sea	u
Pomarine Jaeger	*Stercorarius pomarinus*	m	Ocean	u
Parasitic Jaeger	*Stercorarius parasiticus*	m	Ocean	u
Long-Tailed Jaeger	*Stercorarius longicaudus*	m	Ocean	u
Heermann's Gull	*Larus heermanni*	m	Ocean, estuary	c
Franklin's Gull	*Larus pipixcan*	w	Prairies, marshes, lakes in winter, coastal ocean	u
Bonaparte's Gull	*Larus philadelphia*	m	Ocean, estuary, lakes	
Ring-Billed Gull	*Larus delawarensis*	r⁻	Estuary, lakes, rivers	c
Mew Gull	*Larus canus*	wv	Estuary, ocean, rivers	c
Herring Gull	*Larus argentatus*	wv	Estuary, ocean, lakes	u
California Gull*	*Larus californicus*	r⁻	Estuary, lakes, rivers	c
Glaucous Gull	*Larus hyperboreus*	wv		
Thayer's Gull	*Larus thayeri*	wv		
Western Gull*	*Larus occidentalis*	r*	Estuary, ocean, lakes, islands	c
Glaucous- Winged Gull*	*Larus glaucescens*	r*	Estuary, garbage dumps, fields	c
Black-Legged	*Rissa tridactyla*	wv	Ocean, estuary	u

Kittiwake				
Sabine's Gull	*Xema sabini*	m	Ocean	u
Common Tern	*Sterna hirundo*	wv	Ocean	
Arctic Tern	*Sterna paradisaea*	m	Ocean lakes	u
Forester's Tern	*Sterna forsteri*	✸	Marshes, lakes, bays, beaches, ocean	c
Black Tern*	*Chlidonias niger*	m*	Lakes	r
Caspian Tern	*Sterna caspia*	m*	Lakes, estuary, ocean	u
Common Murre	*Uria aalge*	r*	Ocean, estuary, offshore rocks	c
Pigeon Guillemot*	*Cepphus columba*	r*	Ocean, estuary, offshore rocks	c
Marbled Murrelet	*Brachyramphus marmoratus*	r*	Ocean, estuary	u
Ancient Murrelet (1)	*Synthliboramphus antiquus*	wv⁻	Ocean, estuary	u
Cassin's Auklet*	*Ptychoramphus aleuticus*	r⁻	Ocean, offshore rocks	c
Rhinoceros Auklet*	*Cerorhinca monocerata*	r*	Ocean	c
Tufted Puffin	*Fratercula cirrhata*	wv*	Ocean, offshore rocks	u
Turkey Vulture	*Cathartes aura*	sr*	Woodlands	u
Bald Eagle	*Haliaeetus leucocephalus*	r⁻	Lakes, rivers, marshes	u
Golden Eagle	*Aquila chrysaetos*	wv	Open grasslands and open coniferous forests	
Northern Harrier	*Circus cyaneus*	r*	Fields, marshes, not forests	r
Sharp-shinned Hawk	*Accipiter striatus*	r*	Forests, woodlands	u
Cooper's Hawk	*Accipiter cooperii*	r*	Woodlands	u
Northern Goshawk	*Accipiter gentilis*	r⁻	Forests, mountain woodlands	c
Red-shouldered Hawk	*Buteo lineatus*	wv		
Red-tailed Hawk	*Buteo jamaicensis*	r*	Woodlands, farmlands	c
Rough-legged Hawk	*Buteo lagopus*	wv		
Osprey	*Pandion haliaetus*	sr*	Lakes, rivers	u
Merlin (rare)	*Falco columbarius*	r⁻	Woodlands-grasslands	r
American Kestrel	*Falco sparverius*	r*	Open woodlands-grasslands	r
Peregrine Falcon	*Falco peregrinus*	r*	Open woodlands-grasslands	r
Prairie Falcon	*Falco mexicanus*	wv	Open grasslands and alpine meadows	
Ruffed Grouse	*Bonasa umbellus*	r*	Mixed or deciduous woodland	u
Blue Grouse	*Dendragapus obscurus*	r*	Forest	c
California Quail	*Callipepla californica*	r*	Broken chaparral, woodland edges, coastal	c

			shrub, parks, farms	
Mountain Quail	*Oreortyx pictus*	r*	Woodlots, forests	u
Ring-necked Pheasant	*Phasianus colchicus*	r*	Agricultural areas	u
Wild Turkey	*Meleagris gallopavo*	wv	Open woodlands and riparian areas	
Band-Tailed Pigeon*	*Columba fasciata*	r*	Conifers, mixed woods	c
Rock Dove	*Columba livia*		Cities, farms, cliffs	u
Mourning Dove	*Zenaida macroura*	r*	Fields	u
Yellow-billed Cuckoo	*Cuccyzus americanus*	sr⁻	Thick, closed-canopy riparian forests with an understory of dense brush. Studies show minimum size at least 37 acreswith 7.5 acres of closed canopy.	u
Barn Owl	*Tyto alba*	wv	Open country with abundant rodents	
Short-eared Owl	*Asio flammeus*	wv	Open terrain, marshes, grasslands, agricultural fields	
Long-eared Owl	*Asio otus*	wv	Open coniferous forests and riparian woodlands	
Great Horned Owl*	*Bubo virginianus*	r*	Fields, grassland, woodland	u
Barred owl	*Strix varia*	wv	Coniferous forests dominated by Douglas-fir. Prefers forests with old-growth characteristics	
Spotted Owl	*Strix occidentalis*	r*	Mixed coniferous forests, ususally dominated by Douglas-fir, of more than 1200 acres with multiple layers and closed canopies.	r ✓
Northern Spotted Owl	*Strix occidentalis caurina*		Same as Spotted Owl	
Gyrfalcon	*Falco rusticolus*	wv		
Snowy Owl	*Nyctea scandiaca*	wv	Dunes, fields	u
Western Screech-Owl	*Otus kennicottii*	r*	Grassland, open woodland	u
Northern Pygmy-Owl	*Glaucidium gnoma*	r*	Brush, woodlands	u
Northern Saw-Whet Owl*	*Aegolius acadicus*	r*	Mixed woodlands	u
Burrowing Owl* (1)(3)	*Athene cunicularia*	✸	Open grassland, prairies, dikes, desert, farms	c
Common Nighthawk	*Chordeiles minor*	r*	Nest in open areas and clearings, forage over all habitats including ocean dunes and cities.	
Black Swift	*Cypseloides niger*	m	Open sky, favors mountain country, coastal	u

			cliffs	
Vaux's Swift*	*Chaetura vauxi*	sr*	Mixed woodlands	c
Anna's Hummingbird	*Calypte anna*	sr*	Chapparral hillsides and canyons, sparse forests with open canopies, residential and agricultural areas	
Rufous Hummingbird*	*Selasphorus rufus*	sr*	Open forests near meadows and riparian thickets,	c
Belted Kingfisher	*Ceryle alcyon*	r*	Near water such as rivers, estuaries	c
Northern Flicker	*Colaptes auratus*	r*	Mixed woods	c
Acorn Woodpecker	*Melanerpes formicivorus*	wv	Near oaks	
Lewis' Woodpecker	*Melanerpes lewis*	r	All woods	u
Red-breasted Sapsucker	*Sphyrapicus ruber*	wv	Decidiuous trees within coniferous forests or mxed forests especially near stream or meadows.	
Downy Woodpecker*	*Picoides pubescens*	r*	Mixed forests	u
Hairy Woodpecker	*Picoides villosus*	r*	Mixed woods	u
Pileated Woodpecker	*Dryocopus pileatus*	r*	Large trees, especially snags, most often in Douglas-fir forests with old-growth characteristics	u
Olive-Sided Flycatcher	*Contopus borealis*	sr*	Coniferous forests, open forests preferred	c
Western Wood-Pewee	*Contopus sordidulus*	sr*	Woodlands	c
Hammond's Flycatcher	*Empidonax hammondii*		High coniferous forest	u
Willow Flycatcher	*Empidonax traillii*		Willows along streams flowing through meadows and marshes, also along forests in brushy vegetation	
Alder Flycatcher	*Empidonax alnorum*	sr*	Wooded streams	u
Cordilleran Flycatcher	*Empidonax occidentalis*	wv	Generally east of Cascades, moist dense forests	u
Pacific Slope Flycatcher	*Empidonax difficilis*	sr*	Deciduous woods, coniferous forests	u
Horned Lark	*Eremophila alpestris*	r	Open fields	r
Tree Swallow	*Tachycineta bicolor*	sr*	Rivers, marshes	c
Violet-Green Swallow	*Tachycineta thalassina*	sr*	Open woodland, adjacent to water, urban areas	c
Purple Martin	*Progne subis*	sr*	Open forests, farms, around water	u
Bank Swallow	*Riparia riparia*	sr*	Near water	r

Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*	sr*	Near water	r
Cliff Swallow	*Hirundo pyrrhonota*	sr*	Buildings	c
Barn Swallow	*Hirundo rustica*	sr*	Near water, open areas	c
Western Scrub-Jay	*Aphelocoma californica*	r⁻	Brush, urban	u
Steller's Jay	*Cyanocitta stelleri*	r*	Conifers	c
Gray Jay	*Perisoreus canadensis*	r*	Mountain conifers	u
American Crow	*Corvus brachyrhynchos*	r*	Open woods, farms	c
Common Raven	*Corvus corax*	r*	Mountains, rock scarps	u
Wrentit	*Chamea fasciata*	r*	Mixed woods, brush	c
Black-Capped Chickadee	*Parus atricapillus*	r*	Deciduous woods	c
Mountain Chickadee	*Parus gambeli*	wv	Mid- to high-elevation mixed forests generally above Douglas-fir zone	
Chestnut-Backed Chickadee	*Parus rufescens*	r*	Conifers	c
Bushtit	*Psaltriparus minimus*	r*	Deciuous woods	c
Brown Creeper	*Certhia americana*	r*	Conifers, mixed woods	u
White-Breasted Nuthatch	*Sitta carolinensis*	r*	Deciduous, mixed woods	c
Red-Breasted Nuthatch	*Sitta canadensis*	r*	Conifers, mixed woods	c
House Wren	*Troglodytes aedon*	sr*	Deciduous woods, brush	u
Winter Wren	*Troglodytes troglodytes*	r*	Dense conifers, woods	c
Bewick's Wren	*Thryomanes bewickii*	r*	Decidous woods	c
Marsh Wren	*Cistothorus palustris*	r*	Fresh water marshes	u
Golden-Crowned Kinglet	*Regulus satrapa*	r*	Conifers	c
Ruby-Crowned Kinglet	*Regulus calendula*	wv	Mixed woods	u
Western Bluebird	*Sialia mexicana*	r*	Variety of habitats, but require nest holes or boxes. Forest clear-cuts with standing snags, agricultural areas, riparian woodlands,	
Mountain Bluebird	*Sialia currucoides*		Open terrain with scattered trees	u
Townsend's Solitaire	*Myadestes townsendi*	wv*	Conifers	r
Swainson's Thrush	*Catharus ustulatus*	sr*	Conifers, mixed woods	c

Hermit Thrush	*Catharus guttatus*	r⁻	Deciduous woods, conifers	c
Varied Thrush	*Ixoreus naevius*	r*	Conifers, mixed woods	c
American Robin	*Turdus migratorius*	r*	Fields, residential	c
Loggerhead Shrike	*Lanius ludovicianus*	sr	Fields	u
Northern Shrike	*Lanius excubitor*	wv	Fields	u
American Pipit	*Anthus rubescens*	m	Fileds, mudflats	c
American Dipper	*Cinclus mexicanus*	r*	Rapidly flowing rivers and streams often in coniferous forests, occasionally along mountain ponds and lakes	u
Bohemian Waxwing	*Bombycilla garrulus*		Boreal forests, musket	
Cedar Waxwing	*Bombycilla cedrorum*	r*	Open woods, urban	c
European Starling	*Sturnus vulgaris*	r*	Open fields, farms	c
Hutton's Vireo	*Vireo huttoni*	r*	Conifers, mixed woods	u
Solitary Vireo	*Vireo solitarius*	sr*	Deciduous woods, mixed	u
Red-Eyed Vireo	*Vireo olivaceus*	sr*	Deciduous woods	r
Warbling Vireo	*Vireo gilvus*	sr*	Deciduous woods	c
Orange-Crowned Warbler	*Vermivora celata*	sr*	Brush, low shrubs	c
Nashville Warbler	*Vermivora ruficapilla*	sr*	Brushy slopes	u
Black-Throated Blue Warbler	*Dendroica caerulescens*	sr	Mixed woods	u
Yellow-Rumped Warbler (previously Audobon's Warbler)	*Dendroica coronata*	r*	All types of coniferous and mixed forests. Prefers open forests and forest edges, especially near lakes meadows	c
Black-throated Gray Warbler	*Dendroica nigrescens*	r*	Wide range of forests, woodlands, and brushy areas including clear-cut areas	
Townsend's Warbler	*Dendroica townsendi*	wv⁻	Open forests and forested edges of clear-cuts	u
Hermit Warbler	*Dendroica occidentalis*	sr*	Conifers	c
Yellow Warbler	*Dendroica petechia*	sr*	Stream bottoms	u
Macgillivray's Warbler	*Oporornis tolmiei*	sr*	Mixed woods, brush	
Wilson's Warbler	*Wilsonia pusilla*	sr*	Deciduous and mixed woods	c
Common Yellowthroat	*Geothlypis trichas*	sr*	Fresh-water marshes	c
Black-Headed Grosbeak	*Pheucticus melanocephalus*	sr*	Deciduous woods	c
Lazuli Bunting	*Passerina amoena*	sr*	Brush, stream bottoms	u
Spotted Towhee	*Pipilo maculatus*	r*	Thick brush near open areas	c
Savannah Sparrow	*Passerculus*	wv	Grasslands, fields, pastures, mountain	

	sandwichensis		meadows, wet prairies and grassy areas around lakes and ponds	
Song Sparrow	*Melospiza melodia*	r*	Thickets of deciduous shrubs, ususally willows, along strems, marshes or lakes	c
American Tree Sparrow	*Spizella arborea*	wv		
Chipping Sparrow	*Spizella passerina*	sr*	Open areas with trees	c
Clay-colored Sparrow	*Spizella pallida*	wv		
Dark-eyed Junco	*Junco hyemalis*	r*	Brush, mixed woods	r
Harris' Sparrow	*Zonotrichia querula*	wv		
White-Throated Sparrow	*Zonotrichia albicollis*	m	Open brush	r
White-Crowned Sparrow	*Zonotrichia leucophrys*	r*	Willows, open brush	c
Golden-Crowned Sparrow	*Zonotrichia atricapilla*	wv	Weed patches, brush	c
Fox Sparrow	*Passerella iliaca*	r⁻	Brush	c
Lincoln's Sparrow	*Melospiza lincolnii*	m	Wet meadows	r
Swamp Sparrow	*Melospiza georgiana*	wv		
Lapland Longspur	*Calcarius lapponicus*		Tundra fields, prairies	u
Snow Bunting	*Plectrophenax nivalis*	wv	Tundra, prairies, fields, shores	u
Western Meadowlark	*Sturnella neglecta*	r	Fields	c
Yellow-Headed Blackbird	*Xanthocephalus xanthocephalus*	sr	Marshes	r
Red-Winged Blackbird	*Agelaius phoeniceus*	r*	Marshes, fields	c
Brewer's Blackbird	*Euphagus cyanocephalus*	sr*	Fields, farms	c
Brown-Headed Cowbird	*Molothrus ater*	sr*	Fields, farms	c
Bullock's Oriole	*Icterus bullockii*	r*	River, groves, open oak	c
Western Tanager	*Piranga ludoviciana*	r?*	Conifers, mixed woods	c
House sparrow	*Passer domesticus*	r *	Residential, farms	c
Pine Siskin	*Carduelis pinus*	r*	Conifers, mixed woods	c
American Goldfinch	*Carduelis tristis*	r*	Thickets of shrubs next to weedy fileds, pastures, croplands and open areas in lower-elevation valleys	c
Lesser Goldfinch	*Carduelis psaltria*	r*	Scattered trees and bushes, usually near	u

			water, generally lowlands	
Red Crossbill	*Loxia curvirostra*	r*	Every type of coniferous forest, most common in lower-elevation forests	u
White-Winged Crossbill	*Loxia leucoptera*	r*	Undergrowth, weedy thickets	c
Pine Grosbeak	*Pinicola enucleator*	r	Conifer forests, mixed woods, fruiting trees	c
Purple Finch	*Carpodacus purpureus*	r*	Conifers, deciduous woods	u
House Finch	*Carpodacus mexicanus*	r*	Residential, farms	c
Evening Grosbeak	*Coccothraustes vespertinus*	r*	Conifers, deciduous woods	c

APPENDIX D. ACRONYM LIST

AC	acres
ACW	active channel width
C	Celsius
CFU	colony forming units
CHT	channel habitat type
COE	US Army Corps of Engineers
CRSI	Coastal Salmon Restoration Initiative
DEQ	Department of Environmental Quality
DLCD	Department of Land Conservation and Development
ESA	Endangered Species Act
FPA	Forest Practices Act
GIS	Geographical Information System
gpm	gallons per minute
GWEB	Governor's Watershed Enhancement Board
HU	Habitat Unit
KWG	Kilchis Working Group
LWD	large woody debris
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NWI	National Wetland Inventory
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OHV	off-highway vehicle
ONRC	Oregon Natural Resource Council
OPSW	Oregon Plan for Salmon and Watersheds
OSU	Oregon State University
OWRD	Oregon Water Resources Department
OWRRI	Oregon Water Resource Research Institute
SSCGIS	Oregon State Service Center for GIS
SSO	sand, silt, and organic matter
SWCD	Tillamook Soil and Water Conservation District
TBNEP	Tillamook Bay National Estuary Project
TCCA	Tillamook County Creamery Association
TN	total nitrogen
TP	total phosphorus
TSF	Tillamook State Forest
TSS	total suspended solids
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

APPENDIX E. TBNEP GIS LAYERS PERTINENT TO THE KILCHIS WATERSHED

Layer name	Description	Availability
ALDER	Shape file created by heads-up digitizing locations of riparian enhancements. Locations were hand drawn estimates on USGS 1:24000 topographical maps.	TCWRC
CFSPAWN	Shapefile created from a query of KILRCH showing predicted fall chinook spawning habitat.	TCWRC
CH67_95P	Layer showing change between 1867 and 1995 bathymetry of Tillamook Bay.	Online
CHUMSPAWN	Shapefile created from a query of KILRCH showing predicted chum spawning habitat.	TCWRC
COHOSPAWN	Shapefile created from a query of KILRCH showing predicted coho spawning habitat.	TCWRC
CSSPAWN	Shapefile created from a query of KILRCH showing predicted spring chinook spawning habitat.	TCWRC
CULVERTS	Culvert locations	Online
CURWET	Current wetland generalized habitats. Digitized from USGS topo maps to complement TILAHIST for comparision purposes only.	Online
EELGRASS	Classified image of eelgrass distribution in Tillamook Bay using multispectral airborne imagery.	Online
ESTUHABS	Estuarine habitats, based on Oregon Estuary Plan Book.	Online
HOBO	HOBO temperature monitor locations in the Kilchis watershed.	TCWRC
KILGPS	Culvert locations in the Kilchis watershed that have been located using GPS. Use with KILNOGPS for complete information.	Online
KILHAB	ODFW aquatic/riparian habitat classification for the Kilchis River.	Online
KILNOGPS	Culvert locations in the Kilchis watershed that have been located without using GPS. Use with KILGPS for complete information.	Online
KILRCH	ODFW stream reach information for Kilchis River habitat surveys (KILHAB)	Online
LOWPOLY	Tillamook Bay valley polygons with hydrologic and cultural features.	Online
NCSTSITE	ODFW prioritized stream segments for habitat enhancement.	Online
OWNER	Land owners in the Tillamook Bay watershed.	Online
PREC_CNT	Precipitation contours showing annual average rainfall.	Online
RDALL	All roads in the Tillamook Bay watershed.	Online
SNC96	Extent of Swiss Needle Cast disease in 1996 for all of coastal Oregon.	Online
SNC97	Extent of Swiss Needle Cast disease in 1997 for all of coastal Oregon.	Online
STWSPAWN	Shapefile created from a query of KILRCH showing predicted winter steelhead spawning habitat.	TCWRC
TIL557P	Bathymetry polygons for Tillamook Bay in 1957.	Online
TIL567P	Bathymetry polygons for Tillamook Bay in 1867.	Online
TIL595P	Bathymetry polygons for Tillamook Bay in 1957.	Online
TILAHIST	1867 wetland vegetation communities.	Online
TILLSUB	Major drainage subbasins within the Tillamook Bay watershed.	Online
TILSGRAV	Gravel removal sites in Tillamook County.	TCWRC

Layer name	Description	Availability
TILSTON	Stone and sand removal sites in Tillamook County.	TCWRC
TILVEG	ODF detailed forest vegetation.	ODF
ZONING	County zoning and land use information for Tillamook County.	SSCGIS

Layers available online can be found at http://osu.orst.edu/dept/tbaynep