MIAMI RIVER WATERSHED ASSESSMENT

Final Report

December, 2001

A Report by:

E&S Environmental Chemistry, Inc.
P.O. Box 609
Corvallis, OR 97339

Kai U. Snyder
Timothy J. Sullivan
Richard B. Raymond
Joseph M. Bischoff
Shawn White
Susan K. Binder

Submitted to:

Tillamook County Performance Partnership
P.O. Box 493
Garibaldi, OR 97118

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

We would like to thank the Oregon Watershed Enhancement Board for providing the funds to complete this project. This work was conducted under contract to the Tillamook County Performance Partnership (TCPP). Thanks to Rich Felley and the staff of the TCPP for technical assistance and helpful review comments. Thanks also to Phaedra Bennett and members of the Tillamook Watershed Council for their comments and suggestions.

This report was prepared with assistance from staff at the TCPP and TCWRC. Data and assistance were also provided by numerous state and federal agencies, including ODFW, ODF, SSCGIS, OWRD, and USACE,

Helpful review comments were provided on the draft report by Gus Mayer, Rich Felley, Derek Sowers, Phaedra Bennett, John Gettman, Michele Long, Howard Harrison, Chad Nielsen, Chris Knutsen, Donald LaFrance, and Lisa Phipps.

CHAPTER 1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this watershed assessment is to inventory and characterize watershed conditions of the Miami River watershed and to provide recommendations that address the issues of water quality, fisheries and fish habitat, and watershed hydrology. This assessment was conducted by reviewing and synthesizing existing data sets and some new data collected by the watershed council, following the guidelines outlined in the Oregon Watershed Enhancement Board (OWEB) watershed assessment manual (WPN 1999).

It is important to note that many watershed processes cannot be characterized as either good or bad. Rather, these processes must be evaluated by their likely impact on valued resources such as salmonid habitat or water quantity and quality. By summarizing the existing conditions of the Miami River watershed we hope to help natural resource managers and watershed council members to better understand the complex interactions that occur within the watershed. It is through this understanding that watersheds can be managed to protect the natural resources valued by local and national communities.

This assessment is diagnostic. It does not prescribe specific actions for specific stream segments. The intent of this assessment is to provide a decision-making framework for identifying areas of the watershed in need of protection and restoration. The assessment is conducted on a watershed level, recognizing that all parts of a watershed function as a whole and that alteration or loss of one watershed process or component can affect many other processes and components in the watershed.

The Tillamook Bay National Estuary Project (TBNEP) recently characterized many of the resources in the Tillamook Basin, providing good reference for current conditions in the Tillamook Bay watershed as a whole. Consequently, much of the material in this chapter has been taken directly from the Tillamook Bay Environmental Characterization report produced by the TBNEP.

1.1.1 The Decision Making Framework

A major product of the OWEB watershed assessment method is a set of wall-size maps (housed by the watershed council) to be used as a decision-making framework for selecting appropriate sites for on-the-ground restoration. The maps are organized so that they can be directly related to the U.S. Geological Survey (USGS) 1:24,000 quad sheets. Included on the maps are outlines of the quad sheet boundaries, township section, and range lines. These maps allow the information to be compiled by section (Public Land Survey System) and located. By compiling stream information by section, information can be used to make intelligent, science-based decisions regarding where restoration actions are most likely to be successful. All sites selected from the maps should be field checked before restoration or protection actions are undertaken. Wall-size maps provided to the watershed council include anadromous fish distribution, channel habitat type, riparian conditions, and possible fish barrier locations. Additional data are provided in a digital format to the watershed council. This document supplements and expands on the information contained in the maps and the digital database. The maps in this document, by virtue of their scale, are only intended to provide summary visual representation of the data used in this assessment. They are not meant to provide site-specific information. The wall size maps and digital data should be used for identification of on-the-ground restoration opportunities.

1.1.2 Geographic Information Systems (GIS) Data Used in this Assessment

Geographic Information Systems (GIS) are widely used to store and analyze spatial environmental data for the purposes of evaluating watershed condition and guiding appropriate restoration activities. GIS data are only as accurate as their scale and source data. GIS data must be critically reviewed, and in many cases ground-truthed, to assure an accurate representation of on-the-ground conditions in a watershed. Key GIS data sets were evaluated for confidence in positional accuracy and in representing actual watershed conditions.

The sources of GIS data that were used in the development of this assessment are listed in Table 1.1. Following is a description of each of the principal data layers used in developing this watershed assessment.

<u>Streams (1:24,000):</u> Stream coverages were obtained from the State Service Center for GIS (SSCGIS) and are a part of the Baseline 97 data set. Streams were digitized from the 1:24,000 USGS quads. A visual check of the stream coverage demonstrated that they match the USGS quadrangles, although the positions of the streams were often slightly different from the streams on the aerial photos.

Channel Habitat Types (1:24,000): Stream channels were divided into distinct segments, based on topographic and geomorphic factors. The 1:24,000 stream coverage was attributed with gradient, side slope constraint, and stream-order, and classified into channel habitat type classes according to the protocol outlined in the OWEB manual (WPN 1999).

Land Use (1:24,000): The land use map was created by combining the Western Oregon Land Ownership coverage (developed by OSU), a developed land coverage that was created by Alsea Geospatial for the TBNEP, and NWI wetlands.

Table 1.1 Primary GIS data used in developing this watershed assessment.

Coverage	Scale	Source	Notes
Streams	1:24,000	SSCGIS	
Channel Habitat Types	1:24,000	E&S	Streams attributed by E&S
Land use	1:24,000	E&S; SSCGIS; TBNEP	Created by combining data
Vegetation	30 meter	OSU; USFS; &ODF	CLAMS 1995 LANDSAT
Aerial Photos	1 meter	USDA Farm Service Agency	1990 monochromatic
Watershed Boundaries	1:24,000	Averstar	Created by TCWRC/TCPP
Roads	1:100,000	ODF	Updated DLG (Ad Hoc)
Digital Elevation Models	10 meter	SSCGIS	
Riparian Vegetation	1:24,000	E&S	Attributed 1:24,000 streams from aerial photo interpretation
Riparian Shade	1:24,000	E&S	Attributed 1:24,000 streams from aerial photo interpretation
Salmonid Distribution	1:100,000	ODFW	From field surveys by fisheries biologists
ODFW Habitat Surveys	1:100,000	ODFW	Attributed 1:100,000 streams from field surveys
Debris Flow Potential	1:24,000	ODF	
Points of Diversion	1:24,000	OWRD	Currently being updated

Ownership: Ownership was characterized by Oregon State University using the 1991 Atterbury Ownership maps. This coverage does not include land sales since 1991. It is our assumption that all more recent land sales in the watershed were sales that kept the land in the same category. For example, the sale of Cavenham lands to Willamette Industries kept the land in the Industrial Forest category.

Vegetation: The vegetation characterization was completed using a 1995 LANDSAT image from the Coastal Landscape Analysis and Modeling Study (CLAMS) being conducted jointly by the OSU, USFS Pacific Northwest Research Station, and ODF. The LANDSAT scene was characterized into broadleaf, mixed, and conifer- dominated stands, which were further delineated into four categories based on conifer size (small, medium, large and very large).

Aerial Photos: Monochromatic aerial photos were taken in 1990, and were obtained from the USDA Farm Service Agency. The scale of the photos was 1:7,920.

Watershed Boundaries (1:24,000): Watershed boundaries were specified by the Tillamook County Watershed Resource Center and the Tillamook County Performance Partnership. Sixth-field subwatersheds were obtained from CLAMS.

Roads (1:100,000): Road data were obtained from the Oregon Department of Forestry (ODF). The road coverage utilized was the non-proprietary ODF transportation layer. Railroads and utility access roads were removed from this data set for the purpose of analysis. A more current road layer was created for ODF by a consultant, but at the time of this report the consultant retained rights to the coverage, so it was not available for analysis. An effort is underway by ODF to obtain the rights to this coverage.

Digital Elevation Models (DEMs; 10 m): The 10 m-resolution DEMs were obtained from the SSCGIS. Ten meter resolution refers to the cell size attributed with elevation data. Cell sizes in this coverage are 10 m by 10 m, or approximately 1,000 sq. ft. DEMs were mosaiced and sinks were filled.

Riparian Vegetation and Shade: The 1:24,000 stream coverage was attributed from aerial photo interpretation (see Aerial Photos above). Attributes include vegetation class and shade. Metadata have been provided with the digital data.

Salmonid Distribution (1:100,000): Salmonid distribution coverages were obtained from the Oregon Department of Fish and Wildlife (ODFW). ODFW mapped current salmonid distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. Theses coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*http://www.dfw.state.or.us*).

ODFW Fish Habitat Surveys (1:100,000): Field surveys of stream channel conditions by ODFW were attributed onto 1:100,000 scale stream layers. Two layers exist, including habitat units and reach level data. Reach level data generalize habitat unit data to give an overview of current habitat conditions. Reach level data can be used as a reference point for later comparative work or for the analysis of overall stream conditions. Habitat data include all of the unit data for the entire survey and provide a representation of the condition of the stream at the time of survey. These data change annually since streams are dynamic systems.

National Wetlands Inventory (1:24,000): The primary source for wetland information used in this assessment was the National Wetlands Inventory (NWI) maps created by the U.S. Fish and Wildlife Service (USFWS). Very few of the NWI quads had been digitized by USFWS for the Miami River watershed, so information was generally derived from hard copy NWI maps. It is important to note that NWI wetland maps are based on aerial photo interpretation and not on ground-based inventories of wetlands. On-the-ground inventories of wetlands often find extensive wetlands that are not included on the NWI maps.

Dikes: (1:24,000): The dikes coverage was created by the Watershed Ecosystem Team of the University of Washington. The data represent 1964 conditions, and have not been field-checked for current accuracy. It was based on the Soil Conservation Service soil survey.

Debris Flow Potential: The ODF created debris flow hazard maps based on underlying bedrock geology, slope steepness, historical landslide information, and stream channel confinement where applicable. Slope data were generated from 1:24,000 DEMs. These maps were created to show areas where on-the-ground investigation is prudent before conducting land management and development activities that could be impacted by debris flows.

Points of Diversion (1:24,000): Points of diversion were mapped by the Oregon Water Resources Department (OWRD) by digitizing individual water rights into a township coverage. Only permitted and certificated rights were digitized. All water rights should be up-to-date and maintained by OWRD. Links from points of diversion to actual water rights were found to be missing in this assessment, which was probably due to the database needing to be updated (Bob Harmon, OWRD, pers. comm.).

1.1.3 Data Confidence

GIS data vary in how well they represent actual on-the-ground conditions. Several of the data sets used to develop this assessment need to be evaluated and compared to on-the-ground conditions before restoration actions are taken or final conclusions are made about ecosystem processes. Data sets in need of further evaluation have been listed in the Recommendations section of this document. A few of these will be discussed here because they have characteristics that must be kept in mind while reading this document.

Land Use and Wetlands

The consistency of data quality is uneven for this layer, because it is a composite from several sources. The base information was the Western Oregon Forest Ownership, which provides broad coverage, although it is somewhat out-of-date. The TBNEP land coverage layer and NWI wetlands layers that were merged into this coverage improve data quality in the lowland areas, but wetlands in the uplands are probably under-represented. Also, the TBNEP land development coverage was not originally created as a general land use layer, so less attention was given to undeveloped zones in the lowlands.

Roads

The roads coverage is a key coverage used to evaluate potential sediment sources and changes in watershed hydrology associated with road construction. However, it is not clear that the road coverage accurately represents on-the-ground conditions in this watershed. The road coverage was developed from the 1:100,000 USGS digital line graphs. These coverages were then updated on an ad-hoc basis from aerial photos and other information as it became available. A visual comparison of the data to aerial photos found the roads coverage to be fairly thorough. Although this coverage represents the best available data for roads, the data are nevertheless somewhat suspect. More ground-truthing should be conducted to determine the accuracy of the roads data.

Channel Habitat Types

Channel habitat types (CHTs) were determined for this assessment using GIS. Streams were divided into habitat types based on stream size, gradient, valley width, and ecoregion, according to OWEB protocols (WPN 1999). Minimum length of a habit type was 1,000 ft. CHTs provide an overall indication of the quality and distribution of various stream and associated riparian habitats throughout the watershed. Additional field-based assessment will be required for site-specific restoration activities.

Riparian Vegetation and Shade

Riparian conditions need to be further evaluated and ground-truthed before restoration actions occur. A visual comparison of field checks to the aerial photo interpretations found the data to be fairly consistent. After site selection using the GIS data, any stream reach identified for further action should be field-checked for actual on-the-ground conditions. A more rigorous analysis of the GIS data could also be performed (field data have been provided to the watershed council).

Overall, the confidence in the GIS data is moderate to good for watershed-level assessment purposes. Collection of field data is always recommended; however, field data collection is expensive, time consuming and often unfeasible for very large areas. Time can be saved by using the GIS data to select possible sites for restoration. Field verification can then define the exact conditions present. Used in this way, the GIS data can provide an extremely efficient decision-making framework to guide restoration activities.

1.2 Setting

Like most Pacific Northwest estuaries, Tillamook Bay is part of a coastal, temperate rainforest ecosystem. The Bay is surrounded by rich forests associated with the Oregon Coast Range. With mean annual precipitation around 90 inches (229 cm) per year in the lower elevations and close to 200 inches (510 cm) per year in the higher elevations, the watershed's coniferous forests — trees such as Douglas fir, true fir, spruce, cedar, and hemlock — cover about 89% of the total land area. Hardwood species such as alder and maple also grow throughout the region, especially as second growth in riparian areas. Most of the older trees have been lost to fire and timber harvest. Today, Douglas fir is the dominant tree species in the Tillamook Bay watershed. Foresters describe this environment as a highly productive ecosystem — from both biological and commodity perspectives (TBNEP 1998).

In the lower elevations of the watershed, forest gives way to alluvial plains used for dairy farming and rural residential housing. Early settlers recognized the rich agricultural potential of the lowlands and drained the wetland areas with ditches. Once characterized by meandering rivers and networks of wetlands and small channels that provided fish habitat, woody debris, and organic matter, today's 40 mi^2 (104 km^2) lowland supports about 28,600 dairy cattle (calculated in 1,000- pound units, including calves, heifers and dry stock; TBNEP 1998) and produces 95% of Oregon's cheese. Cattle also produce hundreds of thousands of tons of manure annually and much of the bacteria that washes into the estuary (TBNEP 1998).

The Miami River watershed is one of five fifth field watersheds that drain into Tillamook Bay (Figures 1.1, 1.2). Fifth-field watersheds are drainage basins delineated by the State of Oregon with an average size of approximately 50,000 acres, based on USGS's hierarchical system of hydrological unit delineation. The Miami River drains approximately 36.7 sq. mi. of land and is the smallest watershed of the Tillamook Bay drainage. The watershed is

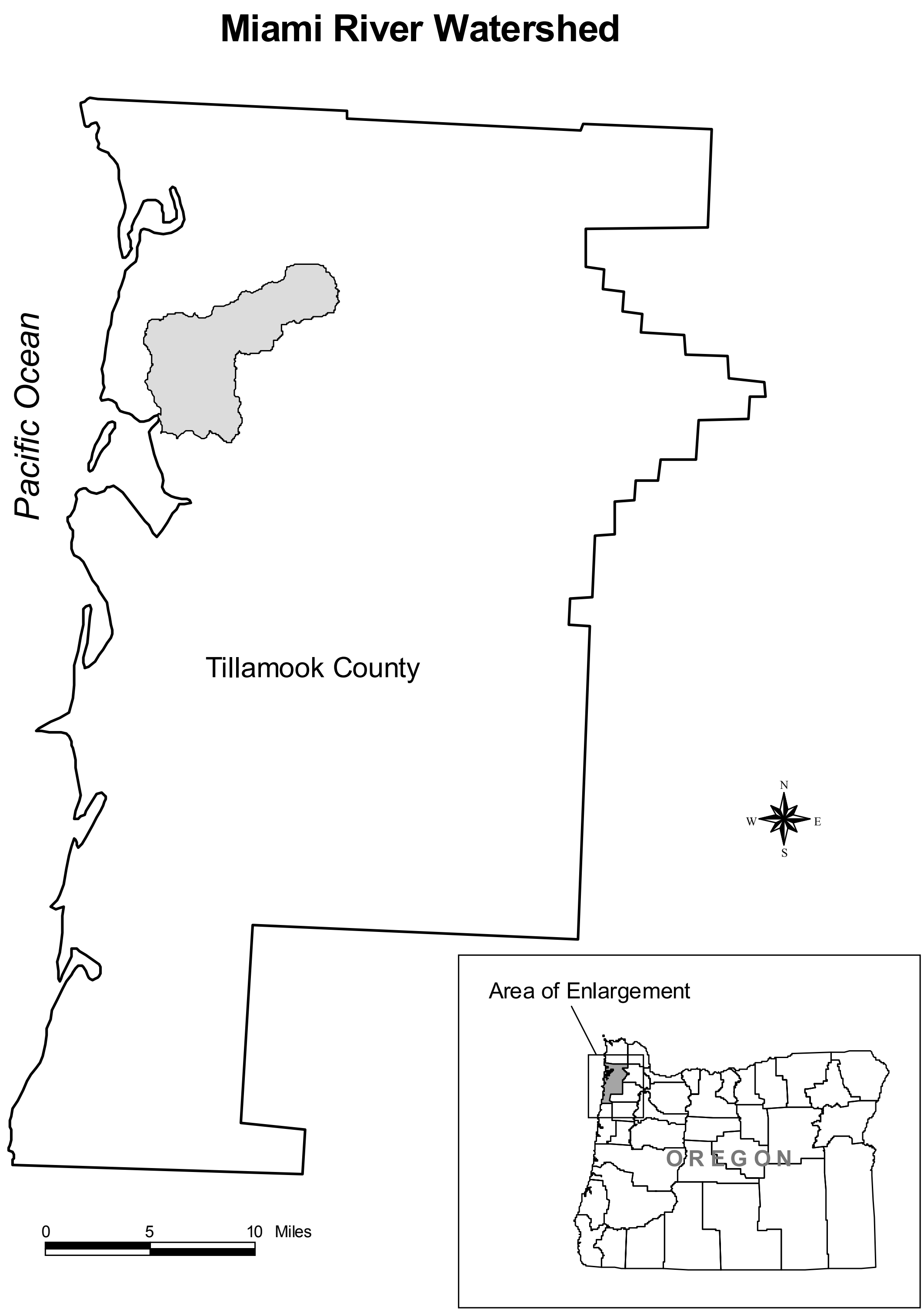


Figure 1.1. Physical location of the Miami River watershed.

Figure 1.2.　Map of Miami River watershed showing subwatershed boundaries and stream network, with names of streams indicated.

characterized by steep forested uplands and flat alluvial lowlands. Much of the higher elevations have been harvested for timber or were burned as a part of the Tillamook Burns and are now second growth forests. The lower Miami River drains agricultural and rural residential areas and enters Tillamook Bay adjacent to the City of Garibaldi.

1.3 Ecoregions

The state of Oregon has been divided into ecoregions based on climate, geology, physiography, vegetation, land use, wildlife and hydrology. Each of these ecoregions has characteristic patterns of climate, geology, topography, and natural vegetation that shape and form the function of the watersheds. Dividing the state and the watersheds into different ecoregions permits regional characteristics to be identified. Most of the Miami River watershed spans portions of two ecoregions: the Coastal Uplands and Volcanics ecoregions.

The Coastal Upland ecoregion extends along the Oregon and Washington coast and is typically associated with the upland areas that drain into the Coastal Lowland ecoregion. The Coastal Upland ecoregion is characterized by coastal upland and headland terraces with medium to high gradient streams. Elevations run from 0 to 500 ft and the land receives 70 to 125 in of precipitation. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, and red alder (Franklin and Dyrness 1973).

The Volcanics ecoregion extends from the upper extent of the Coastal Upland ecoregion to beyond the summit of the Coast Range mountains. The Volcanics ecoregion is characterized by steeply sloped mountains with high-gradient, cascading streams and rivers. Elevations range from 1,000 to 4,000 feet and the region receives 70 to 200 in of precipitation annually. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, and red alder (Franklin and Dyrness 1973).

1.4 Population

Since 1950, the population of Oregon has doubled and Tillamook County's population has increased by approximately 20% (U.S. Bureau of Census 1990). The Tillamook County population declined in the 1960s and rose sharply between 1970 and 1980, largely as a result of fluctuations in the timber industry (Coulton et al. 1996). The County population stabilized during

Table 1.2. Population change in Oregon and Tillamook County since 1950 (TBNEP 1998).

Year	Oregon	Avg. Annual % Change	Tillamook County	Avg. Annual % Change
1950	1,521,341	N/A	18,606	N/A
1960	1,768,687	1.63	18,955	0.19
1970	2,091,385	1.82	18,034	-0.49
1980	2,633,156	2.59	21,164	1.74
1990	2,842,321	0.79	21,570	0.19
1995	3,132,000	1.94	23,300	1.53
2000	3,421,399	1.85	24,262	0.83

Source: U.S. Bureau of Census; Center for Population Research and Census, Portland State University. 1997.

the 1980s and has risen steadily in the 1990s (Table 1.2). 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 (TBNEP 1998).

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 at a rate of 1.5–2% per year (TBNEP 1998).

1.5 Climate and Topography

Topography in the Miami River watershed is typical of the Pacific Northwest coast where the terrain is characterized by steep upland slopes which provide sediment and organic material to the alluvial plain and estuary below. Much of the lowlands were historic floodplains and wetlands that were drained and diked for agricultural and dairy purposes. Elevations in the watershed range from sea level at the mouth to 2,780 ft in the headwaters.

The Miami River watershed experiences a coastal temperate climate strongly influenced by the Pacific Ocean and related weather patterns (Taylor and Hatton 1999). Climate usually includes an extended winter rainy season followed by a dry summer season. Precipitation patterns reflect a strong orographic effect in which precipitation increases with elevation as moist air masses rise over high terrain causing them to cool and drop more precipitation. Mean annual precipitation ranges from about 90 inches in the lowlands to about 200 inches in the highlands (Daly et al. 1994). Rainfall is the primary source of precipitation in the Miami River watershed. From 1961 through 1990, the City of Tillamook averaged 90 inches (229 cm) 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 (2.54 cm). In 1996, however, 126 inches (320 cm) of lowland rain (and very heavy upland rain and snow) led to severe flooding throughout the watershed and caused significant economic and environmental damages.

The seasonal, episodic nature of precipitation defines the natural system. Fall chinook migrate upstream with the first heavy rains in late autumn. Big winter storms cause major landslides in the steeply sloped upland regions. Although heavy storms have characterized the natural system for thousands of years, human activities have exacerbated the impacts and consequences of high rainfall (Coulton et al. 1996). Westerly winds predominate and carry the temperature-moderating effects of the ocean over all of western Oregon. Summers are cool and dry; winters wet and moderate (USDA 1964). Winds blow nearly continuously throughout the year and often reach gale force in the winter. Prevailing winds come from the northwest during the summer and from the south and southwest during the winter (TBNEP 1998).

Temperatures in Tillamook County are moderate. The mean annual temperature is 50.4ºF (10.2ºC), with yearly mean maximum and mean minimum temperatures documented at 59.3ºF (15.1ºC) and 41.6ºF (5.4ºC), respectively. Based on 30 years of data, there is an average of less than one day per year with temperature over 90ºF (32ºC). September had the greatest number of extreme temperatures while July and August recorded the highest temperature of 102ºF (38.89ºC; TBNEP 1998).

1.6 Geology

Tillamook Bay and its watershed are situated in typical Pacific Northwest coastal terrain. A relatively straight coastline consists of miles of sandy beaches punctuated with cliffs of igneous rock and inlets. East of the Pacific Coast, the high, steep ridges of the Coast Range climb up to 3,500 feet (1,064 m). These 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 to very steep terrain of the forested uplands (TBNEP 1998).

In the Tillamook Bay 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 (24 meters). 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 (TBNEP 1998).

1.7 Vegetation

1.7.1 Potential Natural Vegetation

Human activities have greatly altered the vegetation of the Tillamook Bay Watershed. Since the 1850s, European-Americans have cleared and harvested trees, drained wetlands, and established pastures for dairy cattle. In addition, a series of forest fires beginning in the 1930s 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. But the natural, or potential vegetation of the Tillamook Basin is evenly distributed between the Sitka spruce and western hemlock 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 annual precipitation ranging between 118 inches (300 cm) and 78 inches (200 cm). The nearby ocean adds frequent summer fogs and moisture to otherwise dry months and distinguishes the spruce zone from the higher elevation hemlock zone. The temperature averages 51°F (10.6°C) annually with an average

January minimum of 40ºF (4.7ºC) and a July maximum of 70ºF (20.6ºC) at Astoria. The soils are deep, fine textured, typically acid (pH 5.0 to 5.5) and high in organic matter (15–20%; TBNEP 1998).

Dense, tall stands of Sitka spruce, western hemlock, western red cedar, Douglas fir, and grand fir dominate the spruce zone. Hardwood species occurring in the zone include red alder, bigleaf maple (*Acer macrophyllum*), and occasional California bay (*Umbellularia californica*) 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 crytograms. Common native species include sword fern (*Polystichum munitum*), wood sorrel (*Oxalis oregona*), red and evergreen huckleberry (*Vaccinium parvifolium* and *V. ovatum*), salal (*Gaultheria shallon*), red elderberry (*Sambucus racemosa*), and western rhododendron (*Rhododendron macrophyllum*; TBNEP 1998).

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 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 stand. 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 stand can be very slow, due to the shade provided by the dense shrub understory. The resulting communities are either semipermanent brush fields, spruce stands, or red cedar and hemlock that grew on downed logs (TBNEP 1998).

The hemlock zone normally extends in elevation between 450 feet (150 meters) and the subalpine zone of the Coast Range. With less ocean influence and summer fog, the upland hemlock zone still receives heavy precipitation. In fact, the upland regions average up to 142 inches (360 cm) of rain each year with very little precipitation in the late spring to fall period. The zone temperature averages 50ºF (9.6ºC) annually with a January minimum of 30ºF (-0.7ºC) and a July maximum of 78ºF (25.6ºC). The soils are derived from sedimentary and basalt parent materials, of moderate depth and medium acidity, with a high infiltration rate.

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. Hardwood species 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, vine maple (*Acer circinatum*), and Oregon grape (*Mahonia nervosa*) are the most common species (TBNEP 1998).

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, salal, and blackberry species (*Rubus* spp.). Eventually, the shrubs are overtopped by conifers such as Douglas fir (TBNEP 1998).

1.7.2 Historic Floodplain Vegetation

Historically, the Tillamook Valley floodplains were dominated by river bottom forest which consisted of a variety of trees, including black cottonwood, Sitka spruce, red alder, western hemlock, big-leaf maple, and western red cedar **(**Figure 1.3**)**. Spruce trees up to 80 inches in diameter and hemlock 60 inches in diameter were used as bearing trees by the early surveyors. These forested floodplains provided woody debris to the lower river and Bay ecosystems, which added complexity to river patterns and nutrients to the rivers and helped to nurture and sustain fish populations. The forests slowed and regulated flooding across the valley floodplains, reduced erosion, and encouraged sediment deposition (Coulton et al. 1996). These forested bottomlands have been replaced by large open pastures and developed lands with little or no woody vegetation in the riparian areas.

1.7.3 Current Vegetation

Vegetation cover in the Miami River watershed was characterized using the 1995 CLAMS data (Figure 1.4**)**. CLAMS characterized the vegetation by classifying satellite imagery into 15 categories (Table 1.3). The satellite data were acquired in 1988 and updated in 1995. Garono and Brophy (1999) summarized CLAMS data for the Rock Creek watershed by combining these categories to describe the spatial patterns of conifers and open areas. We have used this same approach for the Miami River watershed.

Characterization of the
Tillamook Bay Valley Historical Landscape
Oregon, 1857

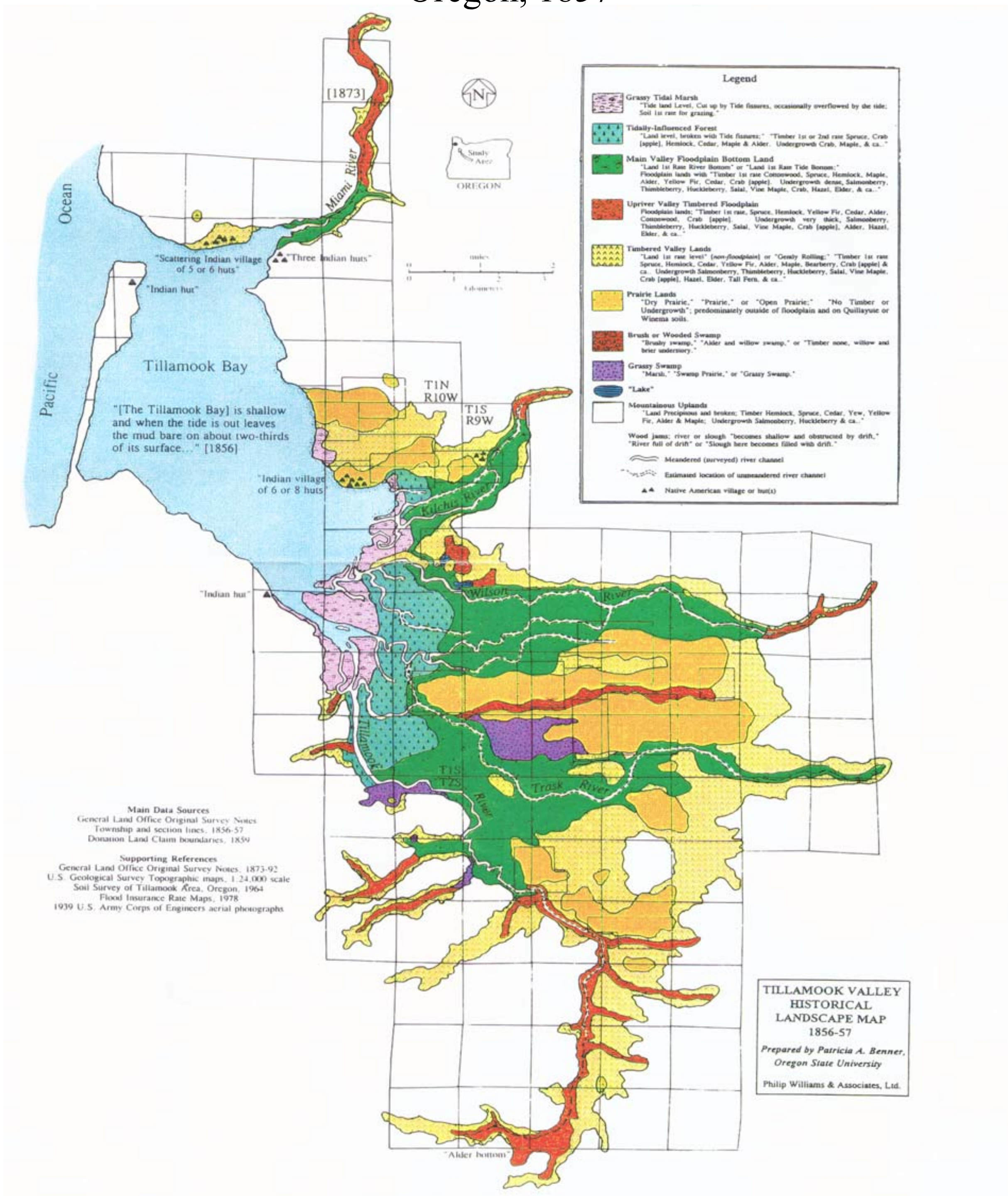
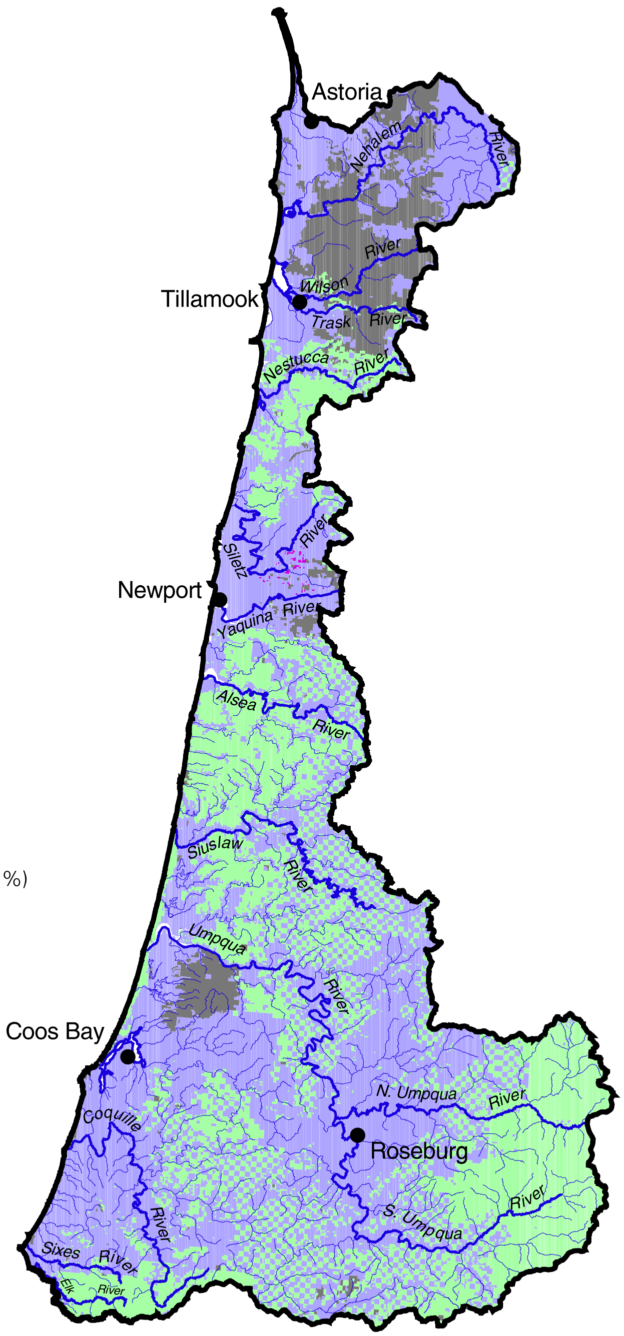


Figure 1.3. Characterization of the Tillamook Bay Valley Historical Landscape, Oregon, 1857 (Coulton et al. 1996).

APPENDIX A

SALMONID ESUs

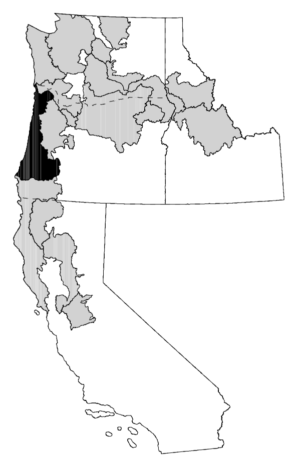
OREGON COAST
CHINOOK SALMON ESU



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (9%)
- Tribal (less than 1%)

Chinook Salmon ESUs



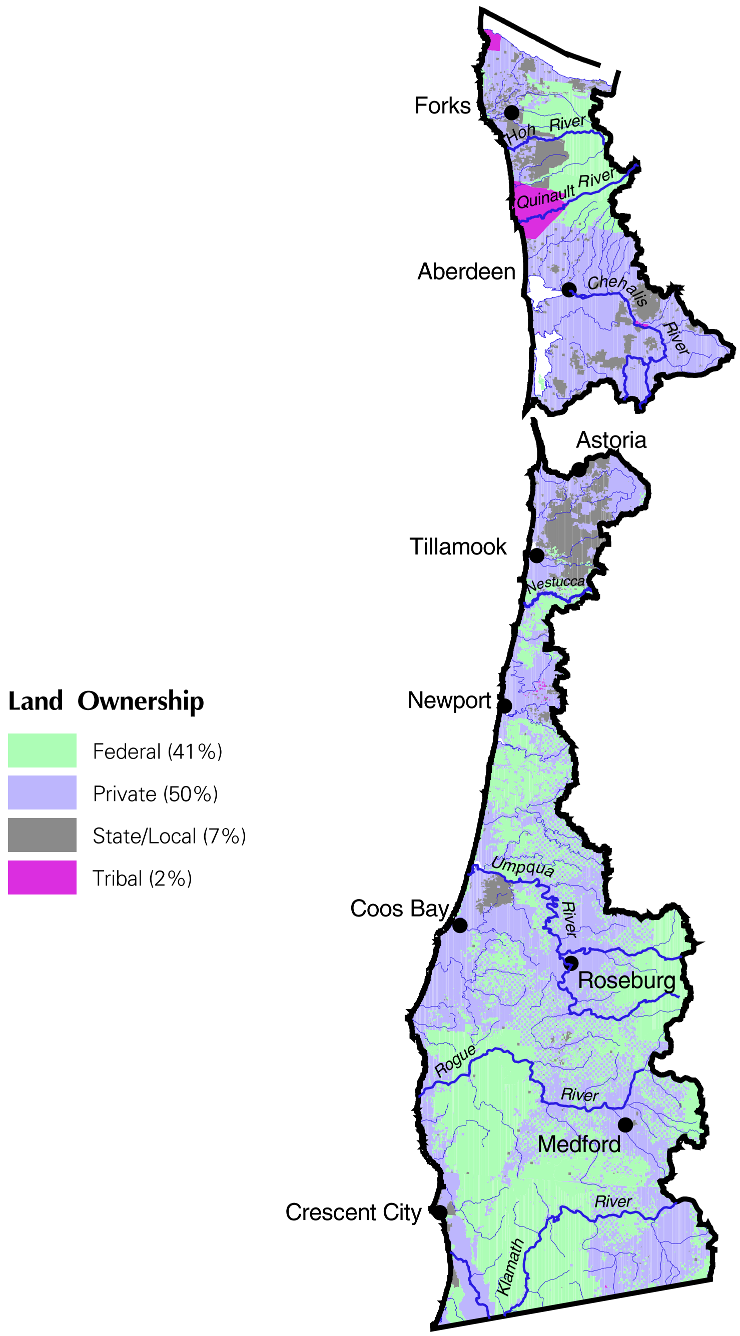
United States Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Oregon St., Suite 410
Portland , OR 97232
Tel (503) 231-2223

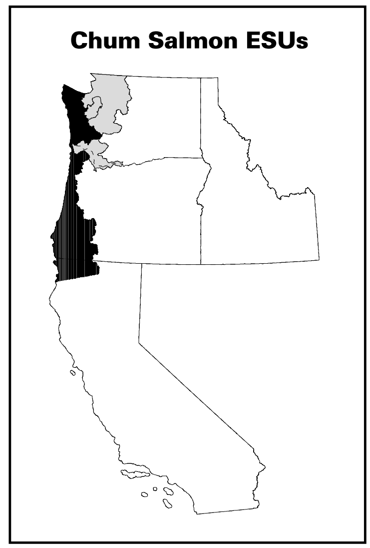
Scale:
10 0 10 20 30 40 Miles
10 0 10 20 30 40 Kilometers

MAP DATE: 2/11/99
CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CHIN

Note: Map is for general reference only.

PACIFIC COAST
CHUM SALMON ESU





Note: Southern boundry of ESU uncertain.

United States Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Oregon St., Suite 410
Portland , OR 97232
Tel (503) 231-2223

Scale:

25 0 25 50 75 Miles

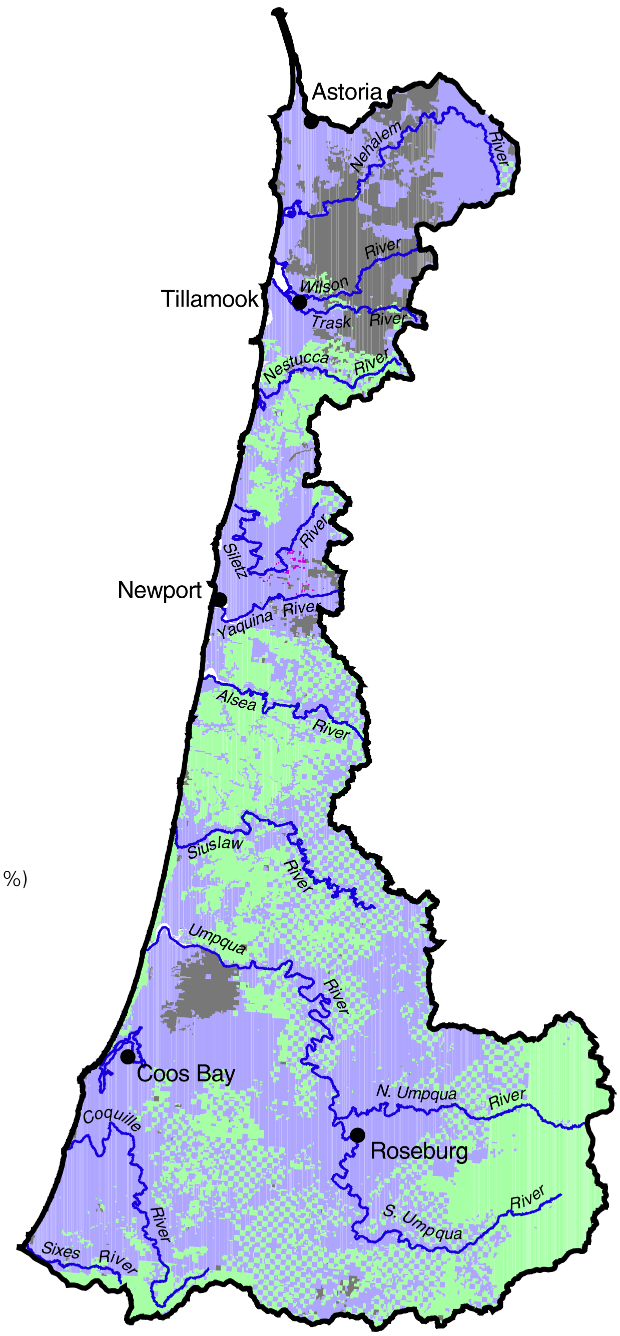
25 0 25 50 75 Kilometers

MAP DATE: 2/11/99

CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CHIN

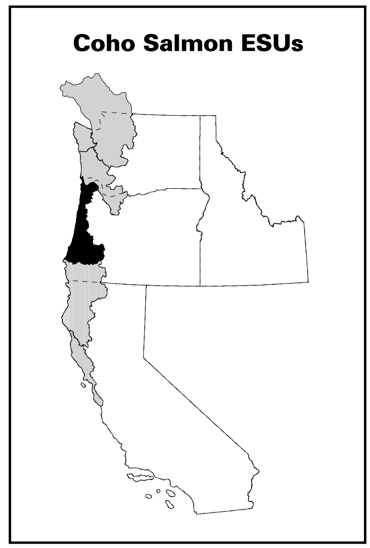
Note: Map is for general reference only.

OREGON COAST
COHO SALMON ESU



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (9%)
- Tribal (less than 1%)



United States Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Oregon St., Suite 410
Portland , OR 97232
Tel (503) 231-2223

Scale:

10 0 10 20 30 40 Miles

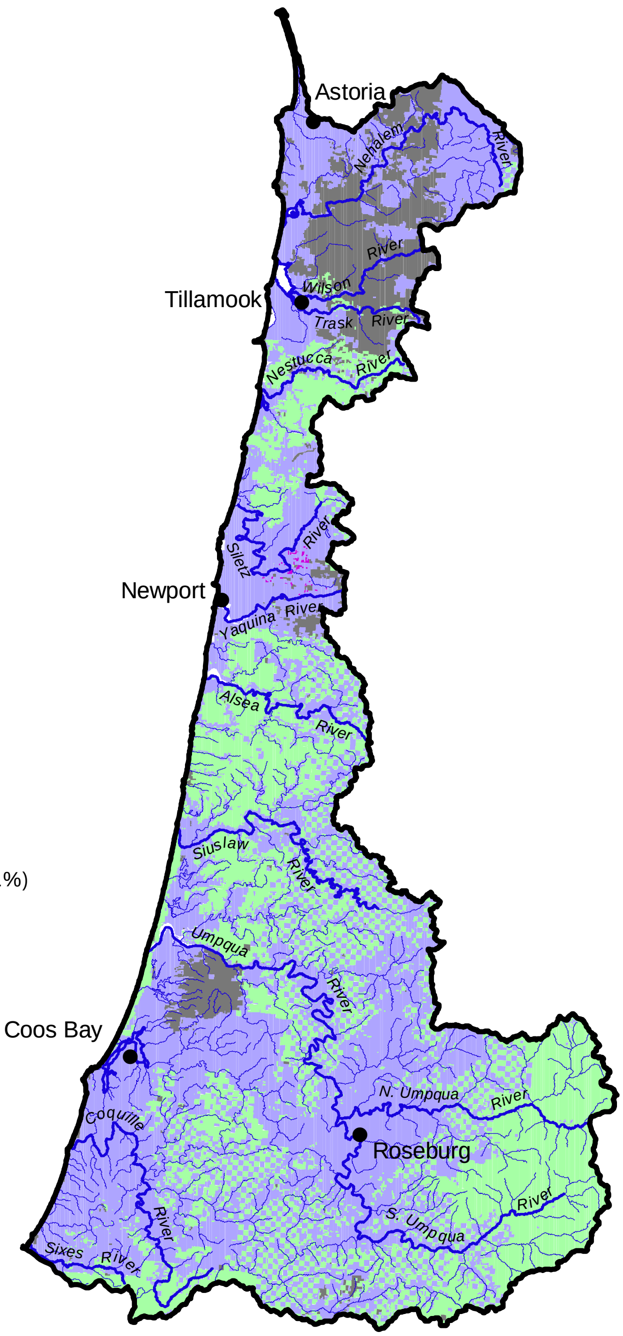
10 0 10 20 30 40 Kilometers

MAP DATE: 2/11/99

CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CHIN

Note: This map is for general reference only.

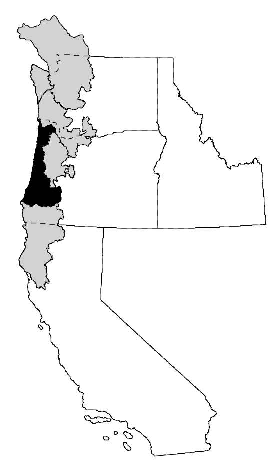
OREGON COASTAL CUTTHROAT TROUT ESU



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (9%)
- Tribal (less than 1%)

Cutthroat Trout ESUs



United States Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Oregon St., Suite 410
Portland , OR 97232
Tel (503) 231-2223

Scale:

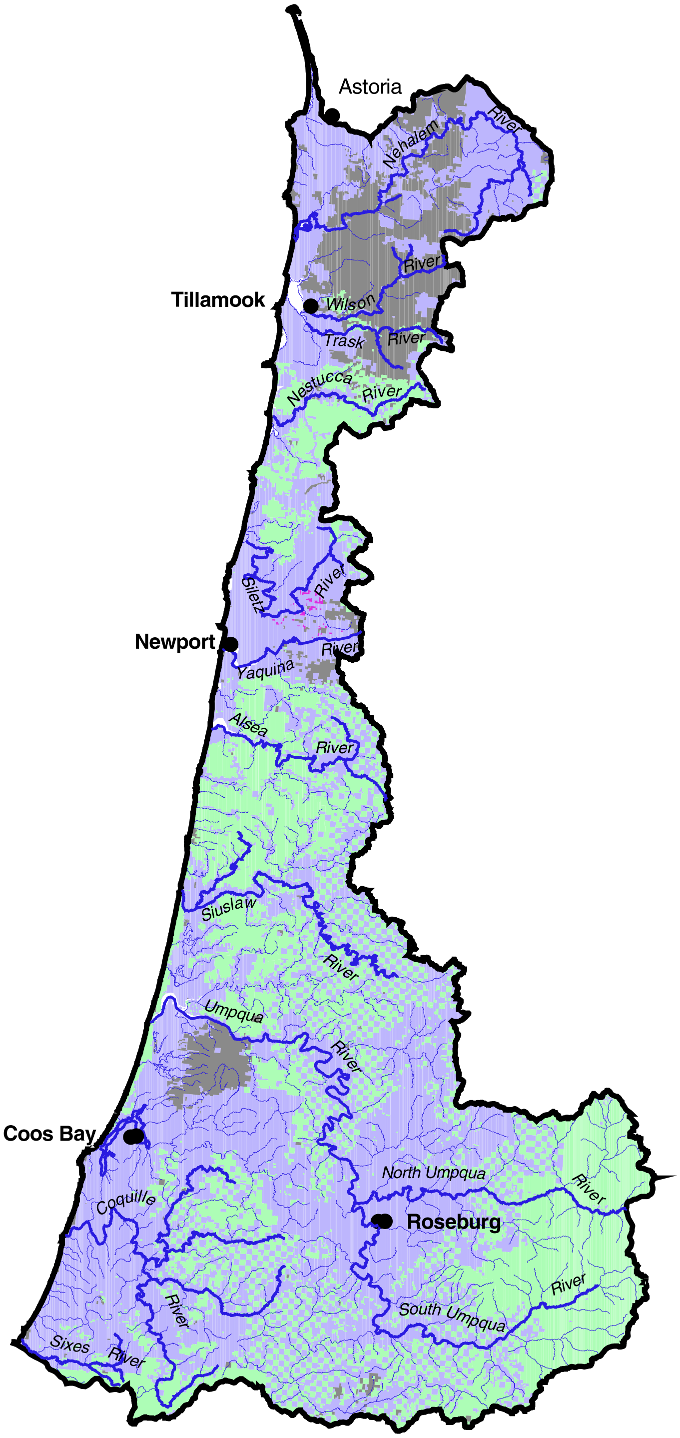
10 0 10 20 30 40 Miles

10 0 10 20 30 40 Kilometers

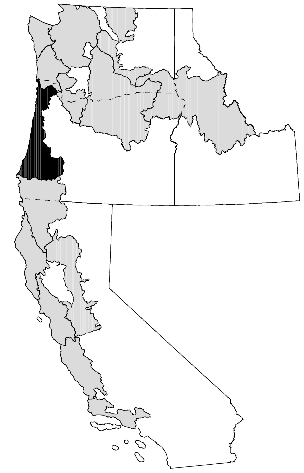
MAP DATE: 2/24/99
CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CUTTS\

Note: Map is for general reference only.

OREGON COAST STEELHEAD ESU



Steelhead ESUs



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (8%)
- Tribal (less than 1%)

United State Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Orregon St., Suite 410
Portland , OR 97232
Tel (503) 231-2223

SCALE:

10 0 10 20 Miles

10 0 10 20 Kilometers

MAP DATE2/17/99

CREATED BY D.A.
HCDGIS\RGN\WS\STONE\STEEL

Note: Map is for general reference only.

APPENDIX B

WATER USE MODEL OUTPUTS

Table 1. Water availability					
Miami River at Mouth					
Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	427.00	.43	426.57	100.00	0.10
2	429.00	.43	428.57	100.00	0.10
3	371	.43	370.57	100.00	0.12
4	150.00	.44	149.56	100.00	0.29
5	88.70	.47	88.23	60.00	0.53
6	52.70	.58	52.12	30.00	1.10
7	32.20	.83	31.37	10.00	2.58
8	36.30	.74	35.56	10.00	2.04
9	90.10	.47	89.63	10.00	0.52
10	349.00	.44	348.56	100.00	0.13
11	483.00	.43	482.57	130.00	0.09
12	164000	.43	163999.57	130.00	0.00

Table 2. Consumptive Uses and Storages									
Miami River at Mouth									
Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.33	.08	.00	.02	.00	.00	.43
2	.00	.00	.33	.08	.00	.02	.00	.00	.43
3	.00	.00	.33	.08	.00	.02	.00	.00	.43
4	.00	.01	.33	.08	.00	.02	.00	.00	.43
5	.00	.04	.33	.08	.00	.02	.00	.00	.43
6	.00	.15	.33	.08	.00	.02	.00	.00	.43
7	.00	.40	.33	.08	.00	.02	.00	.00	.43
8	.00	.31	.33	.08	.00	.02	.00	.00	.43
9	.00	.04	.33	.08	.00	.02	.00	.00	.43
10	.00	.01	.33	.08	.00	.02	.00	.00	.43
11	.00	.00	.33	.08	.00	.02	.00	.00	.43
12	.00	.00	.33	.08	.00	.02	.00	.00	.43

Table 3. Water availability

Moss Creek at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	48.60	.00	48.6	43.00	0.00
2	49.40	.00	49.4	43.00	0.00
3	43.80	.00	43.8	43.00	0.00
4	26.10	.00	26.1	26.10	0.00
5	17.80	.00	17.8	17.80	0.00
6	10.30	.00	10.3	10.30	0.00
7	5.96	.00	5.96	5.97	0.00
8	3.52	.00	3.52	3.53	0.00
9	4.05	.00	4.05	4.06	0.00
10	9.88	.00	9.88	9.90	0.00
11	37.60	.00	37.6	37.60	0.00
12	53.40	.00	53.4	43.00	0.00

Table 4. Consumptive Uses and Storages

Moss Creek at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 5. Water availability

Miami River ab Moss Creek at 14301300

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	345.00	.02	344.98	175.00	0.01
2	346.00	.02	346.00	175.00	0.01
3	300.00	.02	300.00	175.00	0.01
4	179.00	.03	179.00	175.00	0.02
5	120.00	.05	120.00	98.00	0.04
6	71.30	.12	71.20	66.00	0.17
7	41.70	.29	41.40	41.70	0.70
8	25.10	.22	24.90	25.10	0.88
9	28.00	.05	28.00	28.00	0.18
10	70.60	.03	70.60	80.00	0.04
11	282.00	.02	282.00	183.00	0.01
12	390.00	.02	390.00	183.00	0.01

Table 6. Consumptive Uses and Storages

Miami River ab Moss Creek at 14301300

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.02	.00	.00	.02
2	.00	.00	.00	.00	.00	.02	.00	.00	.02
3	.00	.00	.00	.00	.00	.02	.00	.00	.02
4	.00	.01	.00	.00	.00	.02	.00	.00	.03
5	.00	.03	.00	.00	.00	.02	.00	.00	.05
6	.00	.10	.00	.00	.00	.02	.00	.00	.12
7	.00	.27	.00	.00	.00	.02	.00	.00	.29
8	.00	.21	.00	.00	.00	.02	.00	.00	.22
9	.00	.03	.00	.00	.00	.02	.00	.00	.05
10	.00	.01	.00	.00	.00	.02	.00	.00	.03
11	.00	.00	.00	.00	.00	.02	.00	.00	.02
12	.00	.00	.00	.00	.00	.02	.00	.00	.02

Table 7. Water availability

Peterson Creek at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	23.70	0.00	23.70	20.00	0.00
2	24.60	0.00	24.60	20.00	0.00
3	20.50	0.00	20.50	20.00	0.00
4	10.50	0.00	10.50	10.50	0.00
5	5.74	0.00	5.74	5.74	0.00
6	3.79	0.00	3.79	3.74	0.00
7	1.80	0.00	1.80	1.74	0.00
8	0.86	0.00	0.86	0.82	0.00
9	0.69	0.00	0.69	0.65	0.00
10	1.58	0.00	1.58	1.50	0.00
11	9.94	0.00	9.94	9.72	0.00
12	24.90	0.00	24.90	20.00	0.00

Table 8. Consumptive Uses and Storages

Peterson Creek at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 9. Water availability

Prouty Creek at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	13.40	0.01	13.39	13.40	0.07
2	13.60	0.01	13.59	13.60	0.07
3	11.30	0.01	11.29	11.30	0.09
4	5.67	0.01	5.66	5.67	0.18
5	3.08	0.01	3.07	3.08	0.32
6	2.31	0.01	2.30	2.33	0.43
7	1.29	0.02	1.27	1.31	1.55
8	0.68	0.02	0.66	0.69	2.94
9	0.62	0.01	0.61	0.64	1.61
10	1.60	0.01	1.59	1.65	0.63
11	8.20	0.01	8.19	8.30	0.12
12	14.40	0.01	14.39	14.40	0.07

Table 10. Consumptive Uses and Storages

Prouty Creek at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.01	.00	.00	.01
2	.00	.00	.00	.00	.00	.01	.00	.00	.01
3	.00	.00	.00	.00	.00	.01	.00	.00	.01
4	.00	.00	.00	.00	.00	.01	.00	.00	.01
5	.00	.00	.00	.00	.00	.01	.00	.00	.01
6	.00	.00	.00	.00	.00	.01	.00	.00	.01
7	.00	.01	.00	.00	.00	.01	.00	.00	.02
8	.00	.01	.00	.00	.00	.01	.00	.00	.02
9	.00	.00	.00	.00	.00	.01	.00	.00	.01
10	.00	.00	.00	.00	.00	.01	.00	.00	.01
11	.00	.00	.00	.00	.00	.01	.00	.00	.01
12	.00	.00	.00	.00	.00	.01	.00	.00	.01

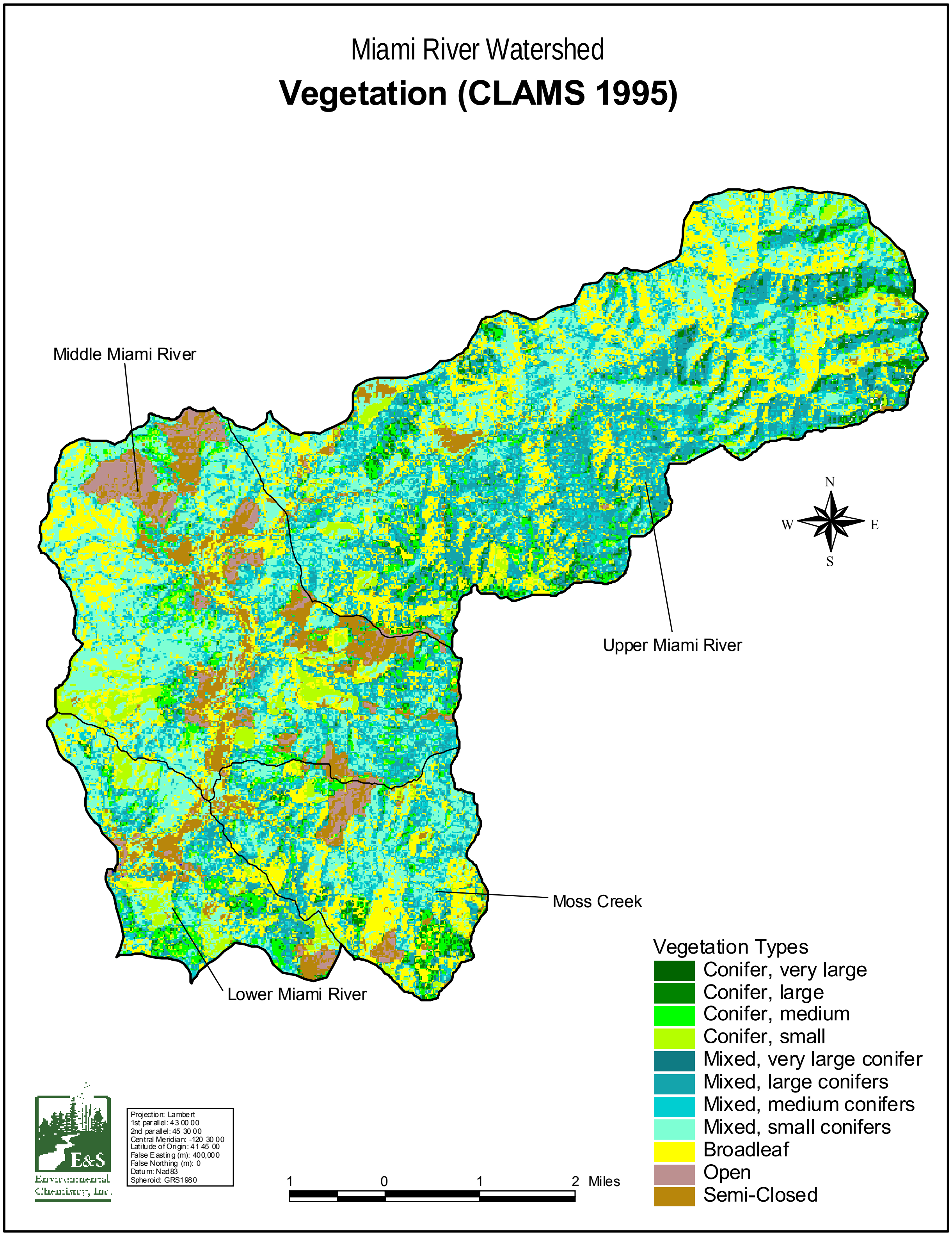


Figure 1.4. Vegetation cover in the Miami River watershed.

Table 1.3. Twelve categories of land cover present in the 1995 CLAMS data set. Categories 0 = background, 2=water, and 5= cloud are not shown (Garono and Brophy 1999). DBH is diameter at breast height.

Class	Cover type	Description
1	Shadow	Background (portions of the data file that do not contain image information)
3	Open	Open (0-40% vegetation cover)
4	Semi-closed	Semi-Closed (41-70% vegetation cover)
6	Broadleaf	Broadleaf (#70% broadleaf cover)
7	Mixed, small conifers	Mixed broadleaf/conifer: <70% broadleaf cover; small conifers (# 1 ft [25 cm] DBH)
8	Mixed, medium conifers	Mixed: <70% broadleaf cover; medium conifers (1-2 ft [26-50 cm] DBH)
9	Mixed, large conifers	Mixed: <70% broadleaf cover; large conifers (2-3 ft [51-75 cm] DBH)
10	Mixed, very large conifers	Mixed: <70% broadleaf cover; very large conifers (> 3 ft [75 cm] DBH)
11	Conifer, small	Conifer: >70% conifer cover, conifers small (#1 ft [25 cm] DBH)
12	Conifer, medium	Conifer: >70% conifer cover, conifers medium (1-2 ft [26-50 cm] DBH)
13	Conifer, large	Conifer: >70% conifer cover; conifers large (2-3 ft [51-75 cm] DBH)
14	Conifer, very large	Conifer: >70% conifer cover; conifers very large (>3 ft [75 cm] DBH)

1.7.4 Large Conifers

Prior to European settlement, Oregon coastal forests were dominated by conifers (Franklin and Dyrness 1973). These forests were changed dramatically by human activities such as forest harvest, replanting, and natural catastrophic events such as the Tillamook Burns, which changed both the age structure and species present in these forests (Garono and Brophy 1999; TBNEP 1998). Conifers, especially old growth, play an important role in ecosystem function in Oregon watersheds by providing shade and large woody debris to streams, slope stabilization, and habitat for wildlife (Naiman and Bilby 1998). Additionally, near-coast stands receive precipitation in the form of fog drip. Old growth forests generate more fog drip precipitation than younger stands. Understanding the age and distribution of conifers within a watershed is essential for managing the system to maintain ecosystem function.

Following the methodology provided in Garono and Brophy (1999), we divided large conifer data into two distinct classes: Mixed Forest/Large Conifers (Classes 9+10+13+14) and Large Conifers (Classes 13+14). The Mixed Forest/Large Conifers class contains those areas that include large conifers, but may be dominated by a broadleaf forest while the Large Conifer Class is actually dominated by large conifers (>70 percent conifer cover). Large conifers are present in 21% of the watershed with the majority occurring in mixed stands (18%; Table 1.4).

Table 1.4. Vegetation cover (%) in the Miami River watershed, based on satellite imaging classification from the 1995 CLAMS study.

Subwatershed	Total Area (sq. mi.)	Broad leaf	Conifer, Large	Conifer, Medium	Conifer, Small	Conifer, Very Large	Mixed, Large Conifers	Mixed, Med. Conifers	Mixed, Sm. Conifers	Mixed, Very Large Conifers	Open	Semi-closed
Lower Miami River	3.9	15.4	2.0	8.4	11.6	0.0	15.7	11.5	23.5	0.8	1.9	9.2
Middle Miami River	11.0	15.2	0.7	5.1	6.9	0.0	9.0	13.5	28.8	0.2	6.3	14.3
Moss Creek	4.6	24.3	3.4	6.2	4.3	0.0	14.6	16.0	21.1	0.8	3.0	6.3
Upper Miami River	17.2	22.6	4.0	4.3	3.7	0.1	22.1	18.5	21.0	1.5	0.2	2.0
Total	36.7	19.9	2.7	5.2	5.5	0.1	17.0	16.0	24.0	0.9	2.6	6.9

Shadow and water categories are not included in this table.

Most of the vegetation in the Miami River watershed is represented by mixed small conifers and broadleaf forest (24 and 20% coverage, respectively), followed by mixed large and medium conifers (17 and 16%, respectively). This vegetation pattern is largely a result of clear cutting activities and the Tillamook Burns. Although many of these areas have been replanted, most have not reached a state of maturity that would allow them to provide many of the watershed processes associated with old growth forests. Replanted stands rarely mimic natural vegetation communities and generally exhibit lower diversity in the overstory community than would be expected from a late-successional community.

1.7.5 Open Areas

Open areas within a watershed can indicate pastureland and meadows as well as recently harvested timberlands. Open areas can have a large influence on hydrology and slope failure (WPN 1999, Naiman and Bilby 1998, Binkley and Brown 1993). The CLAMS data were collected in 1995 and many of the open areas have most likely been replanted since that time. Consequently, these data represent the conditions as they existed in 1995, but not necessarily as they exist today. Pacific Northwest forest ecosystems are constantly in a state of flux, whereby open areas are replanted, and new open areas created through clearcutting or fire. Open areas represent a rather small proportion of the Miami River watershed, accounting for approximately 2.9% of the total area (Table 1.4). Most of the open areas are associated with agricultural practices in the lowlands. Upland open areas are mostly associated with wetlands, which are considered natural open areas in the watershed.

1.8 Land Use

Watershed processes are often affected by land management practices which increase watershed disturbance. For example, management of forest land for timber harvest can influence watershed hydrology (increased peak flows) by increasing road densities and clearing vegetation (WPN 1999; Naiman and Bilby 1998). Wetlands are often drained for agriculture because of their rich organic soils, resulting in habitat loss and the disconnection of floodplains from the rivers. By understanding the land management activities and their associated economic values, land managers and watershed council members can better evaluate the effects of watershed disturbance on their watersheds and plan how to mitigate those impacts on natural ecosystem processes.

The dominant land use in the Miami River watershed is state and private industrial forest, accounting for 60% and 33% of the watershed's total area, respectively (Figure 1.5, Table 1.5). The lowland areas of the watershed along the mainstem are dominated by pastures and private nonindustrial forests. Watershed processes in the Miami River watershed today are most likely affected by changes in forest management, near-stream agricultural activities, increased

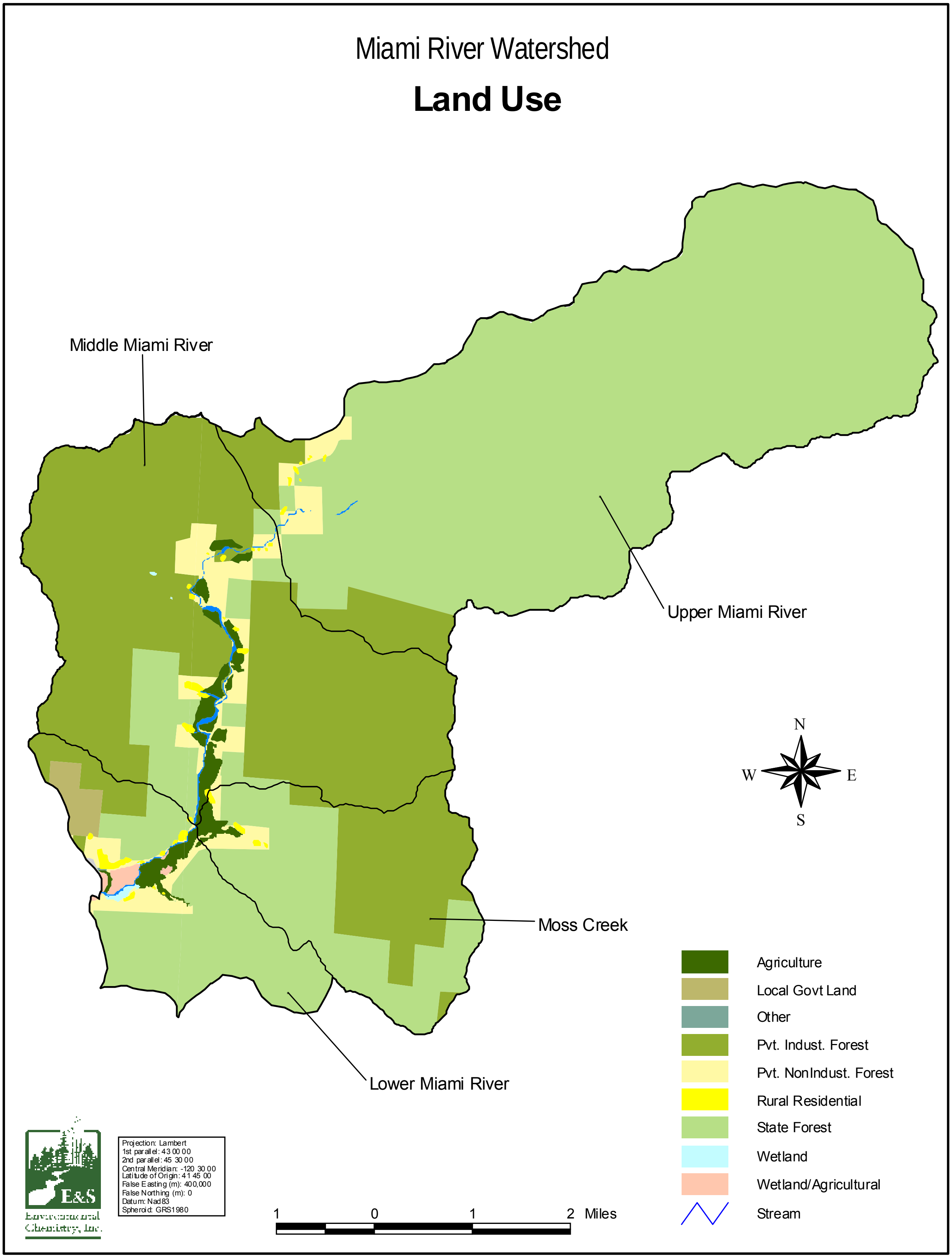


Figure 1.5. Land use in the Miami River watershed. Data displayed are from the refined land use coverage.

Table 1.5. Land use in the Miami River watershed calculated from the refined land use coverage.

	Lower Miami River	Middle Miami River	Moss Creek	Upper Miami River	Total
Watershed Area (sq. mi.)	3.8	11.0	4.6	17.2	36.6
Agriculture (%)	4.14	3.17	1.21	0.00	1.53
Urban (%)	0.14	0.00	0.00	0.00	0.01
Rural Residential (%)	1.56	0.52	0.34	0.08	0.40
Wetland (%)	0.55	0.02	0.00	0.00	0.06
Wetland/agriculture (%)	2.11	0.00	0.00	0.00	0.22
Local Govt Land (%)	6.33	0.00	0.00	0.00	0.66
Pvt.indust.forest (%)	11.26	78.38	44.45	5.20	32.66
Pvt.nonindust.forest (%)	8.34	6.40	2.83	1.76	3.96
State Forest (%)	64.94	10.73	50.58	92.76	59.75

development to accommodate population growth, and floodplain and wetland loss. Specific habitat and water quality related effects typically associated with land use activities are listed in Table 1.6.

1.9 Channel Habitat Types

Stream channels were separated into channel habitat type (CHT) categories using the OWEB protocol (Figure 1.6). Categories were based on stream geomorphic structure, including stream size, gradient, and side-slope constraint (Table 1.7). By identifying current channel forms in the watershed, we can better predict how different channels may respond to particular restoration efforts. Ultimately, changes in watershed processes will affect channel form and produce changes in fish habitat.

Channel responses to changes in ecosystem processes are strongly influenced by channel confinement and gradient (Naiman and Bilby 1998). For example, unconfined channels possess floodplains that mitigate peak flow effects and allow channel migration. In contrast, confined channels translate high flows into higher velocities with greater basal shear stress. Ultimately, these characteristics control stream conditions such as bedload material, sediment transport, and fish habitat quality. Generally, more confined, higher gradient streams demonstrate little

Table 1.6. Typical watershed issues organized by major land use activity (WPN 1999)

Land Use Category	Habitat-Related Effects	Water Quality Effects
Forestry	Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Flow alteration Passage barriers	Temperature Turbidity Fine sediments Pesticides and herbicides
Crop-land grazing	Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Flow alteration Erosion	Temperature Dissolved oxygen Turbidity Fine sediments Suspended sediments Nutrients, bacteria Pesticides and herbicides
Feedlots and dairies	Channel modification	Suspended sediments Nutrients Bacteria Pesticides and herbicides
Urban areas	Flow alteration Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Passage barriers	Temperature Dissolved oxygen Turbidity Suspended sediments Fine sediments Nutrients Organic and inorganic toxics Bacteria
Mining	Channel modification Pool quantity and quality Substrate quality	Turbidity Suspended sediments Fine sediments Nutrients Organic and inorganic toxics
Dams and irrigation works	Flow alteration Channel modification Pool quantity and quality Substrate quality Passage barriers	Temperature Dissolved oxygen Fine sediments
Road networks	Flow alteration Channel modification Pool quantity and quality Substrate quality Passage barriers	Turbidity Suspended sediments Fine sediments

Table 1.7. Channel habitat types found in the Miami River watershed and their associated channel geomorphologic conditions (WPN 1999)

Code	CHT Name	Channel Gradient	Channel Confinement	Channel Size
FP1	Low Gradient Large Floodplain	<1%	Unconfined	Large
FP2	Low Gradient Medium Floodplain	<2%	Unconfined	Medium to large
FP3	Low Gradient Small Floodplain	<2%	Unconfined	Small to medium
LM	Low Gradient Moderately Confined	<2%	Moderately confined	Variable
MM	Moderate Gradient Moderately Confined	2-4%	Moderately confined	Variable
MC	Moderate Gradient Confined	2-4%	Confined	Variable
MV	Moderately Steep Narrow Valley	3-10%	Confined	Small to medium
SV	Steep Narrow Valley	8-16%	Confined	Small
VH	Very Steep Headwater	>16%	Confined	Small

response to watershed disturbances and restoration efforts (Figure 1.6). By grouping the channels into geomorphologic types, we can determine which channels are most responsive to disturbances in the watershed as well as those channels most likely to respond to restoration activities.

Topography in the Miami River watershed is characterized by steep gradient uplands that move quickly into low gradient lowlands. Low gradient streams with extensive floodplains tend to be especially sensitive to the effects of watershed disturbance. However, only 21% of the channels in the Miami River watershed are characterized as low gradient, high sensitivity streams (Table 1.8; Figures 1.6 and 1.7). The majority of the stream segments in the watershed are confined, high gradient streams (58%) that demonstrate a low sensitivity to restoration and watershed disturbance.

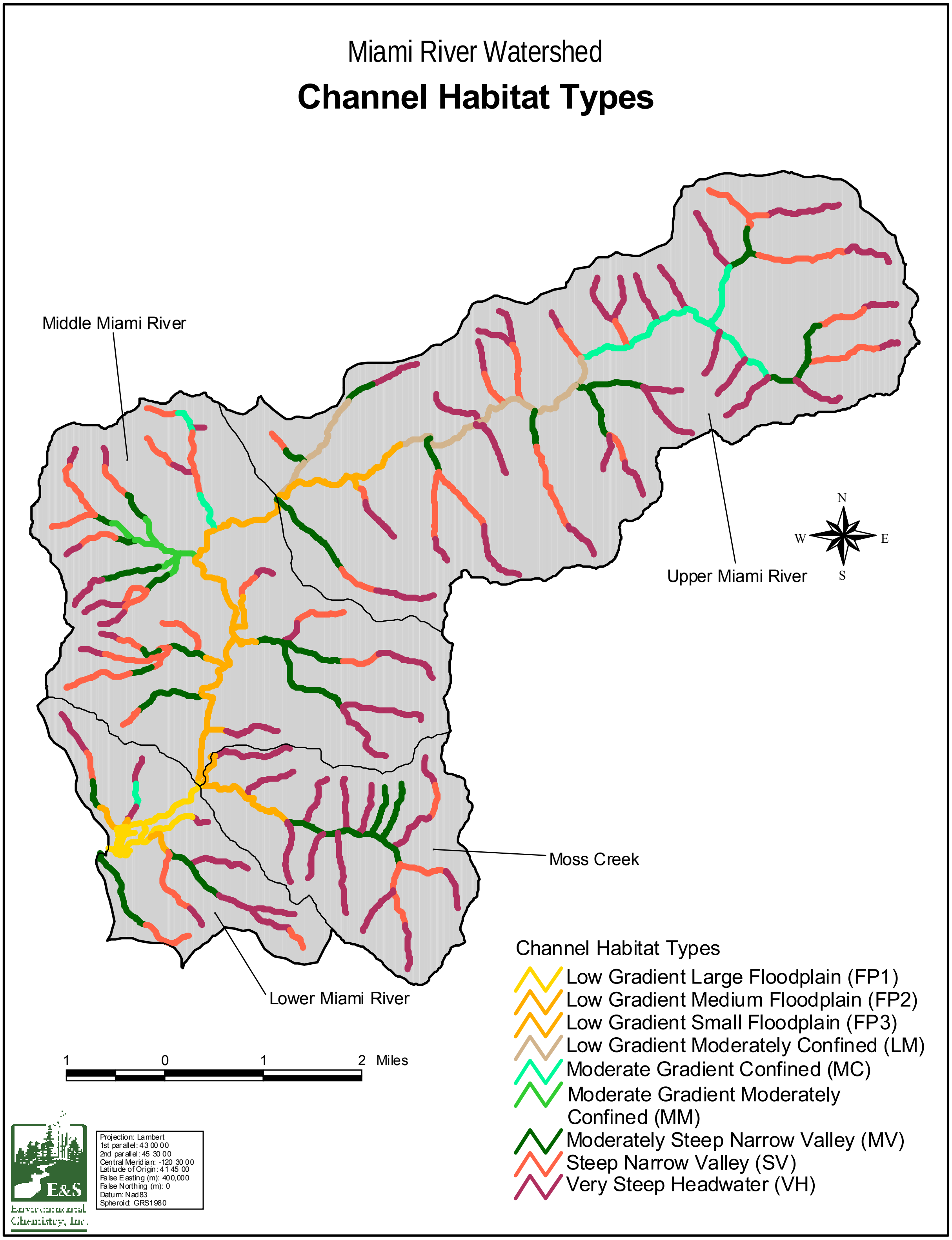


Figure 1.6. Channel habitat types in the Miami River watershed. Stream reaches were classified by slope, size, and side-slope according to OWEB protocols (WPN 1999)

Table 1.8. Channel habitat types in the Miami River watershed. Channel habitat types are grouped by their sensitivity to watershed disturbance.

		PERCENT CHANNEL HABITAT TYPE								
Channel Sensitivity		Low		Moderate		High				
Subwatershed	Stream Length (mi)	% SV	% VH	% MC	% MV	% FP1	% FP2	% FP3	% LM	% MM
Lower Miami River	11.7	16.1	28.9	2.1	17.1	28.1	7.8	0.0	0.0	0.0
Middle Miami River	28.3	29.0	21.5	2.5	19.5	0.0	16.4	4.4	0.0	6.7
Moss Creek	12.9	12.1	58.8	0.0	20.0	0.0	9.1	0.0	0.0	0.0
Upper Miami River	37.4	22.8	39.3	8.5	14.0	0.0	0.0	4.8	10.6	0.0
Grand Total	90.2	22.4	35.1	4.6	17.0	3.6	7.4	3.4	4.4	2.1

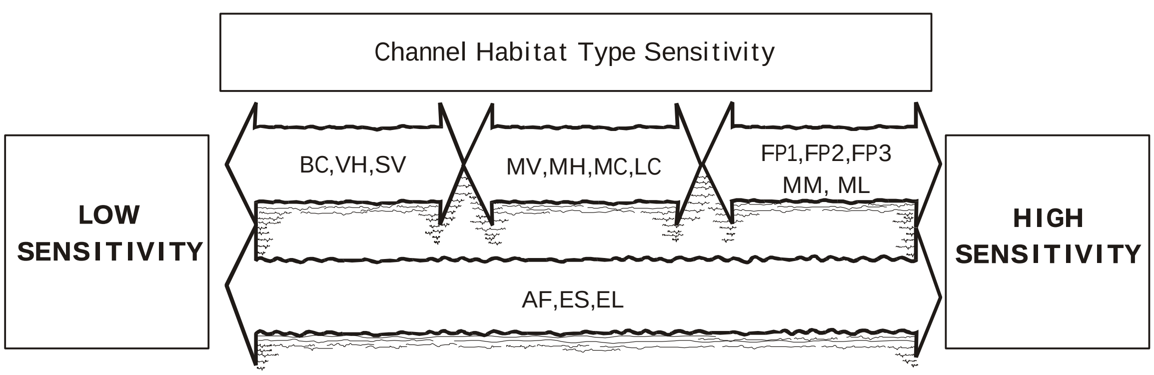


Figure 1.7. Different channel types respond differently to adjustment in channel pattern, location, width, depth, sediment storage, and bed roughness. Such changes may not only result in alteration of aquatic habitat, but the more responsive areas are most likely to exhibit physical changes from land management activities and restoration efforts. (WPN 1999)

1.10 History

The history of a watershed is relevant to the watershed assessment because it provides information on how conditions have changed over time and provides a reference point for current conditions. The history of the Miami River watershed has been compiled in general terms by the TBNEP (An Environmetal History of the Tillamook Bay Estuary and Watershed) and is available through the Tillamook County Performance Partnership. The history section provides insight on issues that relate to landscape features such as aquatic/riparian habitat, fish populations, and water quality. Having information on these prior conditions will allow local stakeholders to develop appropriate reference conditions when conducting and evaluating restoration activities.

1.11 Fire History

The Tillamook Burn, a series of forest fires from 1933 to 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 Tillamook Bay area watersheds, burning some areas repeatedly (TBNEP 1998). 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 the 1960s, timber harvest in the Tillamook Burn area, now the Tillamook State Forest, has been mainly commercial thinning. However, remaining private timber lands have been intensively clear-cut in recent years (TBNEP 1998).

CHAPTER 2. FISHERIES

2.1 Introduction

The OWEB assessment method focuses on watershed processes that affect salmonids and their associated habitats. Understanding the current condition of salmonid populations in a watershed is vital to identifying the effects of the spatial (across space) and temporal (across time) distribution of key habitat areas. Additionally, salmonids are often used as indicator species under the assumption that they are among the most sensitive species in a stream network (WPN 1999, Bottom et al. 1998, Tuchmann et al. 1996). Habitat conditions that are good for salmonids generally reflect good habitat conditions for other species of aquatic biota. Understanding the complex life cycles, spatial distribution, and current status of salmonids in a watershed is key to evaluating watershed management practices and their effects on watershed health.

There is not a great deal of fisheries data available for the Miami River. Most fish surveys in the Tillamook Basin have been conducted in the larger rivers, especially the Wilson and Trask Rivers. We assume, however, that changes in habitat conditions and trends in fisheries status have generally been similar among the various tributary rivers that comprise the Tillamook Basin.

The North Coast Guide to Project Selection (ODFW 1994) provided some specific guidelines and recommendations for restoration site selection in the Miami River watershed. Specific sites were identified for habitat restoration for steelhead, coho, and chum salmon.

2.2 Fish Presence

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. clarkii*). Although details of their life history and habitat requirements differ substantially, all spawn in fresh water, migrate through the estuary, and rear for varying lengths of time in the ocean before returning to their natal (where they hatched) streams to complete their life cycle. Resident cutthroat trout are also present throughout the Tillamook Bay watershed, including the Tillamook, Trask, Wilson, Kilchis, and Miami Rivers.

2.3 Species of Concern

The National Marine Fisheries Service (NMFS) has listed several anadromous fish species that do, or could potentially, exist in the watershed as threatened or as candidates for listing (Table 2.1). Coho salmon have been listed as threatened by NMFS. Coastal cutthroat and winter steelhead are candidates for listing. Listing for chum and chinook was not warranted as determined by NMFS. However, chum are locally depressed, and much of their historic habitat has been affected by human activities in the lower rivers (Michele Long, ODFW, per. comm. 2001). Listing occurs for an entire Evolutionarily Significant Unit (ESU) which is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout (Appendix A).

Table 2.1. Status of anadromous fish occurring in the Miami River watershed.

Fish	ESU	Status
Coho	Oregon Coast	Threatened
Coastal Cutthroat	Oregon Coast	Candidate
Chum	Pacific Coast	Not Warranted
Chinook	Oregon Coast	Not Warranted
Steelhead	Oregon Coast	Candidate

* An Evolutionarily Significant Unit or "ESU" is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

The Endangered Species Act requires that forests providing habitat for endangered species must be protected. Relationships between land cover and the decline of rare species have been established. For example, loss of late successional forests may be related to declines in threatened and endangered species such as the northern spotted owl, marbled murrelet, and coho salmon (Garono and Brophy 1999, Tuchmann et al. 1996). An understanding of the land patterns associated with the distribution of these species can lead to a better understanding of how to conserve them.

Private and state owned lands have their own mandates for the protection and conservation of the habitats related to these threatened and endangered species. Private timber practices in Oregon are regulated by the Forest Practices Act, which was designed to help protect important habitats. The Oregon Department of Forestry (ODF) is developing an assessment and management plan to detail forest management practices within areas occupied by threatened species. Due to the complex interactions in watersheds, forest practices must be considered on both public and private land in order to effectively manage the natural resources for the protection of the critical habitats associated with these species.

Background information on fisheries status is summarized below. Much of the following information was taken directly from ODFW's Biennial Report on the Status of Wild Fish in Oregon (ODFW 1995), from the NMFS website (*http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm*), or from the Tillamook Bay Environmental Characterization report (TBNEP 1998).

The Tillamook Bay National Estuary Project (TBNEP) found that data relating to numbers of adult spawners, numbers of fish harvested, and some rough estimates of the contribution of hatchery fish to the spawning runs are available for some, but not all of the runs. Information regarding the distribution and relative abundance of juvenile salmonids in tributary streams is only beginning to be developed and is not yet adequate to provide a comprehensive overview of status of juvenile salmonids in the watershed. Information on the estuarine distribution and abundance of juvenile salmonids is dated and incomplete. No information is available on smolt production.

Table 2.2 summarizes the findings relative to 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 2.2 is described in the following species-by-species summaries of available information relating to status and trends for the Tillamook Bay salmonids.

2.4 Coho

2.4.1 Life History

The coho salmon (*Oncorhynchus kisutch*) is an anadromous species that rears for part of its life in the Pacific Ocean and returns to freshwater streams in North America to spawn. Coho may spend several weeks to several months in fresh water before spawning, depending on the

Table 2.2. Status and recent population trends of Tillamook Bay anadromous salmonids (TBNEP 1998, Nicholas and Hankin 1988).

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
Steelhead trout		
winter	heavily influenced by hatchery fish, numbers appear low	declining
summer	introduced, supported entirely by hatchery fish	declining
Sea-run cutthroat trout	depressed	possibly declining

distance they migrate to reach their spawning grounds. All adults die within two weeks after spawning. Juveniles normally spend one summer and one winter in fresh water, although they may remain for one or two extra years in the coldest rivers in their range. They migrate to the ocean in the spring, generally one year after emergence, as silvery smolts about four to five inches long. Most adults mature at 3 years of age (ODFW 1995).

2.4.2 *Listing Status* (Source: *http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm*).

Coho Salmon were listed as a threatened species on August 10, 1998 for the Oregon Coast ESU. The ESU includes all naturally spawned populations of coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,606 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.4.3 Population Status

Coho salmon populations along the entire Oregon coast are now considered depressed. 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 (TBNEP 1998).

Historically, the Tillamook Bay Watershed was an important producer of coho salmon (TBNEP 1998). 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 fish. 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, off Oregon and California. The total combined harvest of naturally-produced Tillamook Bay 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 (TBNEP 1998). Note that the high catch in 1991 was an anomaly, in that relatively large numbers of non-Tillamook Bay coho were caught just inside the mouth of the Bay during the latter part of the summer. These fish may have temporarily entered the Bay due to localized abundance of prey species near the mouth of the Bay (TBNEP 1998).

Numbers of adult coho (mostly age 3) escaping to the spawning grounds have been indexed by ODFW in some watersheds, using the peak count method, which is based on repeated counts on the spawning grounds. No consistent survey data have been collected in the Miami River watershed. However, the results of surveys conducted by ODFW on tributaries to the Miami River (Figure 2.1) suggest that either the quality of freshwater habitat has seriously declined since about 1976 or that other factors (*e.g.*, poor ocean survival, over harvesting, influence of hatchery fish, or high estuarine mortality) are limiting the number of returning adults (TBNEP 1998).

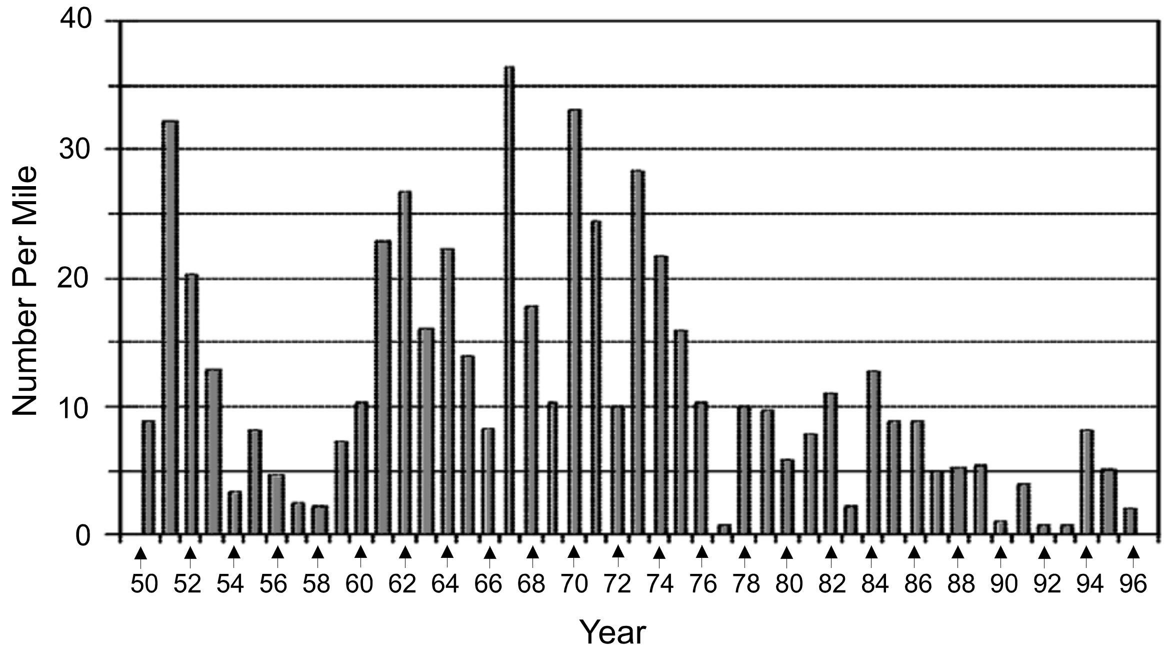


Figure 2.1. Tillamook Bay watershed peak count estimates for coho salmon. Source: TBNEP (1998).

2.4.4 Factors Responsible for Decline

A combination of factors, including rearing and spawning habitat degradation, reduction in summer streamflow, passage impacts at dams, decrease in ocean productivity, excessive fishing, and impacts caused by hatchery programs, have been implicated in most of the declines and extinctions of coho salmon populations in Oregon. There is little in the way of causal information available, however, that is specific to the Miami River watershed. We assume that the observed decline in coho salmon abundance in this watershed has similar causes to the observed declines elsewhere.

Coho salmon evolved in freshwater ecosystems that were historically characterized by a high degree of structural complexity, including the presence of large wood, flood plains, braided channels, beaver ponds and, in some cases, lakes. Anthropogenic (human) activities, including timber harvest, mining, water withdrawals, livestock grazing, road construction, stream channelization, diking of wetlands, waste disposal, gravel removal, farming, urbanization, and splash dam logging have altered most freshwater ecosystems. In the last 15 years, the productivity of the marine environment used by Oregon coho also has declined. This decline in ocean productivity appears to be part of a long-term, apparently natural cycle in ocean conditions that is outside of management influence. These decreases in freshwater and marine habitat condition have coincided with several decades of increasing releases of hatchery coho salmon and sustained high harvest rates. Wild populations have declined, and the range of coho salmon in Oregon has contracted concurrent with these activities and processes (ODFW 1995).

In coastal rivers and lower Columbia Basin tributaries, low summer flows and the loss of complex in-stream structure, winter side channels, sloughs, and shade have been predominant problems. Timber harvest in the coastal temperate rain forest belt has contributed to winter habitat loss, particularly in the upper reaches of basins. Logging has caused the loss of large conifers from riparian areas that would have provided long-lasting in-stream structure when they fell into streams. Siltation from logging roads, road-failures, and loss of ground cover, along with reduction of water filtering and shade due to the removal of riparian vegetation, have reduced egg and juvenile survival. Agriculture, industrialization, and urbanization have degraded coho rearing habitat in the lower reaches and estuaries of many coastal streams through such actions as diverting water, channelizing streams, diking off-channel and estuary areas, and releasing effluents that elevate temperatures and reduce water quality (ODFW 1995). It is likely that all of these factors have played important roles in coho decline within the Miami River watershed. The relative importance of each, and the segments of river most heavily impacted, are poorly known.

2.4.5 Species Distribution

ODFW mapped current coho distribution by attributing 1:100,000 stream coverages based on survey data, and best professional judgment of local fish biologists. The mapped distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Coho salmon utilize as habitat the entire mainstem of the Miami River watershed, including all of the major tributary streams (Figure 2.2). The Miami River is thus extensively used by coho salmon (ODFW 1995), but there are no specific locations on the Miami River that are known or believed to contain high densities of spawning coho. A fair portion of the upper mainstem (RM 5.5 to RM 11) is moderate to low gradient forested land that is suitable for coho spawning and rearing habitat.

Figure 2.2. Coho distribution in the Miami River watershed (ODFW 2000)

2.4.6 Hatcheries

Hatchery coho were stocked in the Tillamook system, practically without interruption, from 1902 to the early 1990s. 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.

There is evidence to suggest that hatchery coho may have contributed to the decline of wild coho salmon. Hatchery programs supported historical harvest rates in mixed-stock fisheries that were excessive for sustained wild fish production (TBNEP 1998). Hatchery coho may have also strayed to spawn with wild fish, which may have reduced the fitness and therefore survival of the wild populations through outbreeding depression (c.f., Hemmingston et al. 1986; Flemming and Gross 1989, 1993; Hjort and Schreck 1982; Reisenbichler 1988), and which can lower effective population sizes (Ryman and Laikre 1991). Finally, hatcheries may have reduced survival of wild juveniles through increased competition for limited food in streams, bays, and the ocean in years of low ocean productivity, through attraction of predators during mass migrations, and through initiation or aggravation of disease problems (Nickelson et al. 1986).

The influence of hatchery fish on naturally-spawning populations is not known. However, it appears that spawning is now earlier than in the past, suggesting that hatchery fish may have had an influence (TBNEP 1995). 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 (ODFW 1995).

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 (including the Miami, Kilchis, Wilson, and Tillamook Rivers). Chilcote and Lewis (1995) suggested that this practice was likely responsible for the shift in spawn timing among the natural spawners. However, they recommended additional studies before making definitive statements 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. A shift to early spawning could increase mortality by subjecting more of the incubating embryos in the gravel to bedload movements caused by early winter storms. Reducing variability in the schedule of the coho life stages might also increase competition for food and habitat.

Coho stocking was discontinued in the early 1990s in the Tillamook basin. At that time, fry releases (including in the Miami) were also discontinued (Keith Brown, ODFW, pers. comm., September, 2001).

2.5 Chinook

2.5.1 Life History

Oregon chinook salmon populations exhibit a wider range of life history strategies than coho or chum salmon, with variation in the date, size and age at juvenile ocean entry; in ocean migration patterns; and in adult migration season, spawning habitat selection, age at maturity and size (Nicholas and Hankin 1989; Healey 1994). Generally, subyearling juveniles rear in coastal streams from three to six months and rear in estuaries from one week to five months. Nearly all Oregon coastal chinook salmon enter the ocean during their first summer or fall (ODFW 1995).

Fall chinook salmon are present in the Miami River watershed. Mature fall chinook (2 to 6 years of age) return to all five of the major Tillamook Bay subbasins from early September through mid-February. Peak entry into the rivers occurs in mid-October, and chinook spawning from October to January. Spring chinook salmon occur primarily in the Trask and Wilson Rivers, with a small population in the Kilchis River.

2.5.2 Listing Status (Source: *http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm*).

On March 9, 1998, NMFS determined that chinook listing was not warranted for the Oregon Coast ESU. The ESU includes all naturally spawned populations of chinook salmon in Oregon coastal basins north of, and including, the Elk River. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,604 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.5.3 Population Status

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 spring and fall chinook salmon were packed annually on Tillamook Bay from 1893 through 1919. The packing of chinook salmon was very erratic during this period 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 (TBNEP 1998).

The recreational catch of chinook salmon has been estimated since 1969 from annual returns of salmon/steelhead punch cards (Nicholas and Hankin 1988, Nickelson *et al.* 1992, ODFW 1995, Kostow 1996). These catch estimates indicate a generally increasing trend from 1969 through 1993 (period of available data) for fall chinook salmon (TBNEP 1998). 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 only long-term direct counts of the number of adult chinook salmon reaching the spawning grounds (fish that have “escaped” the fishery) 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 a number of times during the spawning season. The 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 (TBNEP 1998). Botkin 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.

2.5.4 Factors Responsible for Decline

The causes of declines of some chinook salmon populations vary substantially for different regions of the state, depending largely on human-related changes to each watershed, and also upon ocean migration routes used by different populations. Fall chinook in small south coast streams have declined due to loss or degradation of spawning habitat, elevation of summer water temperatures, and loss or degradation of estuarine rearing areas (ODFW 1995). These populations are also distributed into an area of ocean that was at a low productivity level during the early 1990s. Populations of far north-migrating wild fall chinook in north coastal rivers like the Miami appear to be stable or increasing, largely due to their migration into an area where ocean conditions generally have been favorable for at least a decade (although they have more recently been degraded), to improvements in mainstem spawning habitat, and to decreases in ocean harvest rates as a result of annually-negotiated fishing regimes under the Pacific Salmon Treaty between the United States and Canada.

There is little information available that is specific to the Miami River watershed regarding environmental changes that may have adversely affected the quality of chinook habitat. General information regarding such issues is summarized below.

Spawning chinook salmon in Oregon's small coastal streams tend to concentrate in high densities on gravel bars in specific river reaches. Fall chinook adults may move directly to the spawning beds after river entry, but spring chinook adults require deep, cold holding pools reasonably near spawning areas where they hold and mature for four to six months prior to spawning. This holding period occurs during the summer when flows are naturally lowest and water temperatures are warmest. Fall chinook are more restricted by minor migration barriers such as culverts or berms than are coho or steelhead. Habitat alterations that affect the abundance, stability and accessibility of mainstem gravel bars impact all chinook. Habitat alterations that eliminate large holding pools in the area of spawning beds seriously impact spring chinook (ODFW 1995).

Coastal juvenile chinook salmon rear for several months during their first spring in lower river mainstems, using deep riffles, woody debris and shoreline riparian vegetation for cover and feeding areas. Juveniles move into estuaries generally by late June or July where they continue rearing through the summer. Most chinook juveniles in populations along the central coast enter the ocean in the fall. Lower basin habitat complexity, summer flows, and estuary productivity affect rearing chinook salmon.

Freshwater habitat alterations that have impacted chinook salmon along the mid- to north Oregon coast are primarily associated with historical logging practices and, in the Tillamook Bay Basin, with natural events that deforested, channelized, scoured and destabilized mainstem spawning areas. Logging and agricultural practices, and urban development also decreased the complexity and productivity of lower mainstem reaches and estuaries. In many areas, impacts due to natural winter storm events have increased due to riparian deforestation, stream channelization, and bank destabilization.

Ownership of forested land along the mid- to north Oregon coast includes state and federal public forest lands, as well as private forest. The state lands are in Tillamook State Forest, which dominates the basins that drain into Tillamook Bay. This state forest was formed when private land holdings in the area were heavily impacted by a series of severe forest fires between 1918 and 1951, collectively called the "Tillamook Burn." The fires, and the extensive salvage logging that followed, deforested most of the Wilson and Trask basins, and impacted substantial portions of the Kilchis and Miami basins. The deforested basins were unprotected from subsequent winter storm events that destabilized streambanks, caused severe erosion and sedimentation, and scoured and channelized lower mainstem reaches. This area has been recovering since the 1960s and is now vegetated by young coniferous and red alder forest. Uplands, streambanks and stream channels are now stabilizing and conditions for fall chinook are improving, although heavily impacted by floods of 1996, 1998, and 1999. Spring chinook continue to be impacted by the loss of deep holding pools, which have not been reestablished (ODFW 1995).

Private lands have been extensively logged. Recent improvements in logging on private lands, associated with the adoption of Oregon's Forest Practices Act, can be expected to further improve riparian areas. Mainstem spawning habitat associated with forested lands along the coast have progressively improved for fall chinook over the last three decades although deep holding pools for spring chinook are still inadequate.

Much of the road construction in the Coast Range has been associated with logging. Major roads into the Coast Range have typically been placed along the relatively moderate gradients of river mainstems and have contributed to mainstem channelization. Roads in upland forestlands also contribute to erosion (ODFW 1995).

Agricultural and logging practices along low gradient river reaches in lower basins have greatly decreased the complexity and productivity of juvenile chinook rearing areas. Wetlands, marshes and braided channels have been straightened, channelized, diked, drained and deforested to create croplands and pastures. Summer flows and water quality have also decreased and summer water temperatures have increased in these areas.

The impacts in the lower basins continue downriver to the estuaries where agricultural and urban development are dominant land uses. Many wetlands adjacent to estuaries have been diked, filled or drained to provide land for development. Many of the estuaries associated with urban centers have also been dredged and jetties have been constructed to provide boat access. These activities have changed currents in the estuaries. Changes in estuary productivity are difficult to assess, but incidental observations made by some ODFW district staff suggest that fish species assemblages in some bays are becoming less diverse, which suggests that a decrease in productivity has occurred.

2.5.5 Species Distribution

ODFW mapped current chinook distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Fall chinook are found throughout the watershed including the entire mainstem and most of the major tributary streams (Figure 2.3). The region from the confluence of Moss Creek (RM1) upstream to RM 11 is used extensively by spawning fall chinook. Although spring chinook are found in the Tillamook Basin, they are not currently found in the Miami River watershed.

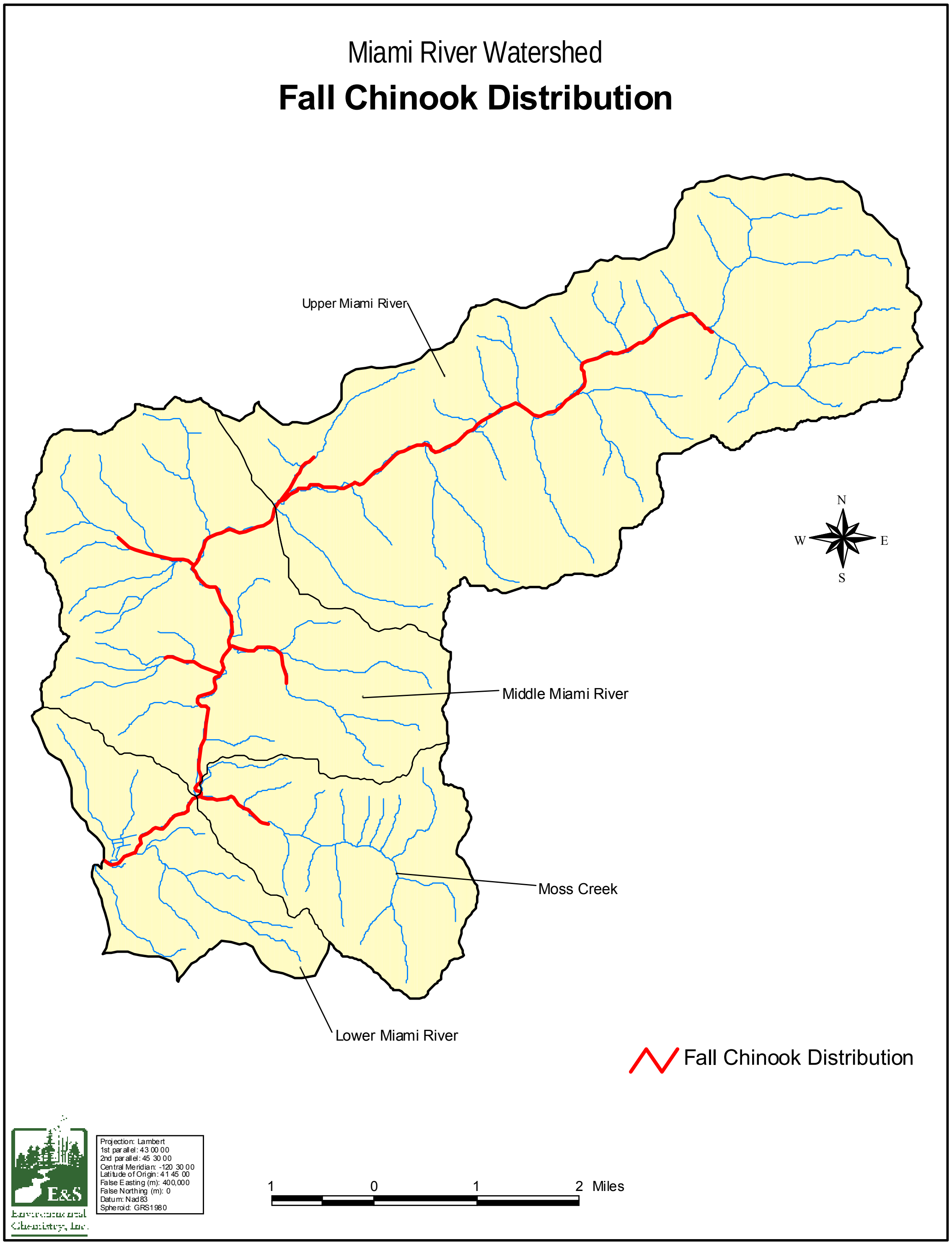


Figure 2.3. Fall chinook distribution in the Miami River watershed (ODFW 2000).

2.6 Coastal Cutthroat

2.6.1 Life History

Coastal cutthroat trout exhibit diverse patterns in life history and migration behaviors. Populations of coastal cutthroat trout show marked differences in their preferred rearing environments (river, lake, estuary, or ocean); size and age at migration; timing of migrations; age at maturity; and frequency of repeat spawning. Anadromous or sea-run populations migrate to the ocean (or estuary) for usually less than a year before returning to fresh water. Anadromous cutthroat trout either spawn during the first winter or spring after their return or undergo a second ocean migration before maturing and spawning in fresh water. Anadromous cutthroat are present in most coastal rivers. Nonmigratory (resident) forms of coastal cutthroat trout occur in small headwater streams and exhibit little in-stream movement. They generally are smaller, become sexually mature at a younger age, and may have a shorter life span than many migratory cutthroat trout populations. Resident cutthroat trout populations are often isolated and restricted above waterfall barriers, but may also coexist with other life history types.

2.6.2 Listing Status (Source: http://www.nwr.noaa.gov/1salmon/ salmesa/inde3.htm).

On April 5, 1999, NMFS determined that coastal cutthroat listing was not warranted for the Oregon Coast ESU. However, the ESU is designated as a candidate for listing due to concerns over specific risk factors. The ESU includes populations of coastal cutthroat trout in Oregon coastal streams south of the Columbia River and north of Cape Blanco (including the Umpqua River Basin, where cutthroat trout were listed as an endangered species in 1996). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,606 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.6.3 Population Status

Less is known about the present status of sea-run cutthroat trout than about any of the other anadromous salmonid species in the Tillamook Bay 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

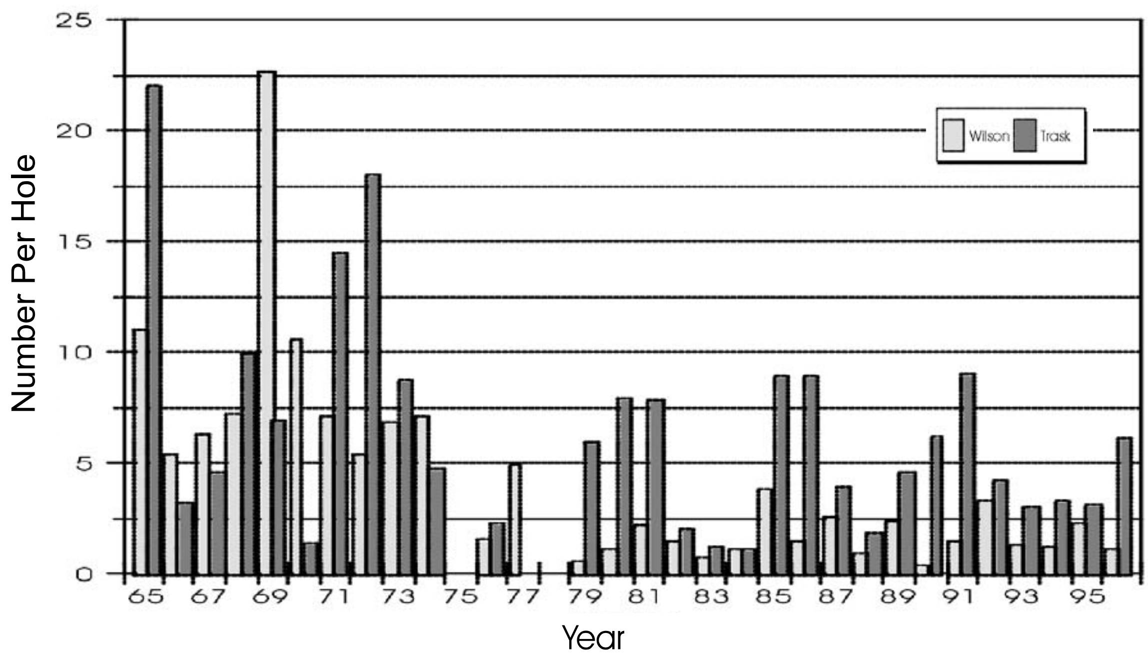


Figure 2.4. Resting pool counts of sea-run cutthroat trout for the Wilson and Trask Rivers. Lacking site-specific data, we assume that trends for the Miami River are probably proportional to those documented for the Trask and Wilson Rivers. Source: TBNEP (1998).

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 cutthroat trout angling regulations were changed to "catch and release" only (TBNEP 1998). 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 (Emmett et al. 1991).

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 (Figure 2.4). 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 (Figure 2.4). 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.

2.6.4 Factors for Decline

Coastal cutthroat trout tend to spawn in very small (first and second order) tributaries. Young fry move into channel margin and backwater habitats during the first several weeks. During the winter, juvenile cutthroat trout use low velocity pools and side channels with complex habitat created by large wood. Specific information regarding habitat utilization in the Miami River watershed, and changes over time in habitat quality, is not available.

Very little is known about the habitat requirements and preferences of sea-run cutthroat trout in estuarine environments. Juvenile and adult cutthroat trout spend considerable time in tidal rivers and low-gradient estuarine sloughs and tributaries during spawning and feeding migrations. Large wood likely is an important habitat component for cutthroat trout during their estuarine residence. They appear to remain near shore, probably near the mouth of their natal river, during their marine occupancy.

2.6.5 Species Distribution

Anadromous cutthroat trout have not been mapped by ODFW. However, ODFW identified populations that use the majority of the Miami River watershed. Resident populations exist in Moss and Minich Creek reaches (ODFW 1995). Anadromous cutthroat populations were identified in the mainstem Miami River as well as all of the subwatersheds.

2.6.6 Species Interactions

Cutthroat trout populations with different life history patterns may co-occur in the same river. The level of genetic exchange between cutthroat trout of different life history types, for example, between sea-run and resident forms, is poorly understood (ODFW 1995). A single population may exhibit several life histories; or the life histories may form separate breeding populations through assortative mating, but still exchange low levels of gene flow; or the life history types may form completely reproductively isolated gene pools. Extensive genetic and life history surveys will be needed to clarify these relationships.

Habitat use by juvenile cutthroat trout is affected by interactions with other salmonids, although the extent of the effect is poorly understood. It is known, however, that whereas juveniles prefer to rear in pools, young-of-the-year cutthroat trout may be displaced into low gradient riffles, particularly by the more dominant coho salmon. The selection of small tributaries for spawning and early rearing may help to reduce competitive interactions between cutthroat trout and steelhead trout or coho salmon. Differential selection of spawning habitat also may help to minimize hybridization with rainbow/ steelhead trout (ODFW 1995).

2.7 Chum

2.7.1 Life History

The chum salmon is an anadromous species that rears in the Pacific and Arctic oceans and spawns in freshwater streams in North America. Most of the chum salmon life span is spent in a marine environment. Adults typically enter spawning streams ripe, promptly spawn, and die within two weeks of arrival. Most spawning runs are over a short distance, although exceptionally long runs occur in some watersheds in Asia and Alaska. Adults are strong swimmers, but poor jumpers and are restricted to spawning areas below barriers, including minor barriers that are easily passed by other anadromous species. Juveniles are intolerant of prolonged exposure to fresh water and migrate to estuarine waters promptly after emergence. A brief residence in an estuarine environment appears to be important for smoltification and for early feeding and growth. Movement offshore occurs when the juveniles reach full saltwater tolerance and have grown to a size that allows them to feed on larger organisms and avoid predators. Chum salmon mature at 2 to 6 years of age and may reach sizes over 40 pounds (ODFW 1995).

2.7.2 Listing Status (Source: *http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm*).

On March 10, 1998, NMFS determined that chum salmon listing was not warranted for the Pacific Coast ESU. The ESU includes all naturally spawned populations of chum salmon from the Pacific coasts of California, Oregon, and Washington, west of the Elwha River on the Strait of Juan de Fuca. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,152 square miles in Oregon and Washington. The following counties lie partially or wholly within these basins: Oregon - Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill; Washington - Clallam, Cowlitz, Grays Harbor, Jefferson, Lewis, Mason, Pacific, Thurston, and Wahkiakum.

Although chum listing was not considered warranted for the entire Pacific Coast ESU, chum populations are locally depressed (Michele Long, ODFW, pers. comm., June, 2001).

2.7.3 Population Status

Tillamook Bay historically supported the Oregon Coast's largest chum salmon fishery (TBNEP 1998). 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 legally 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 River watersheds (Figure 2.5). 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 is 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 (TBNEP 1998).

2.7.4 Factors Responsible for Decline

Chum salmon spawning habitat has been impacted in Oregon (and presumably in the Miami River watershed) by siltation, channelization and gravel extraction. Siltation of spawning gravels has resulted from road construction, road failures, and logging. Access to historical spawning areas has been blocked by structures that continue to be passable by other anadromous fish, including tidegates, culverts, and gravel berms. Degradation of estuaries due to diking, water

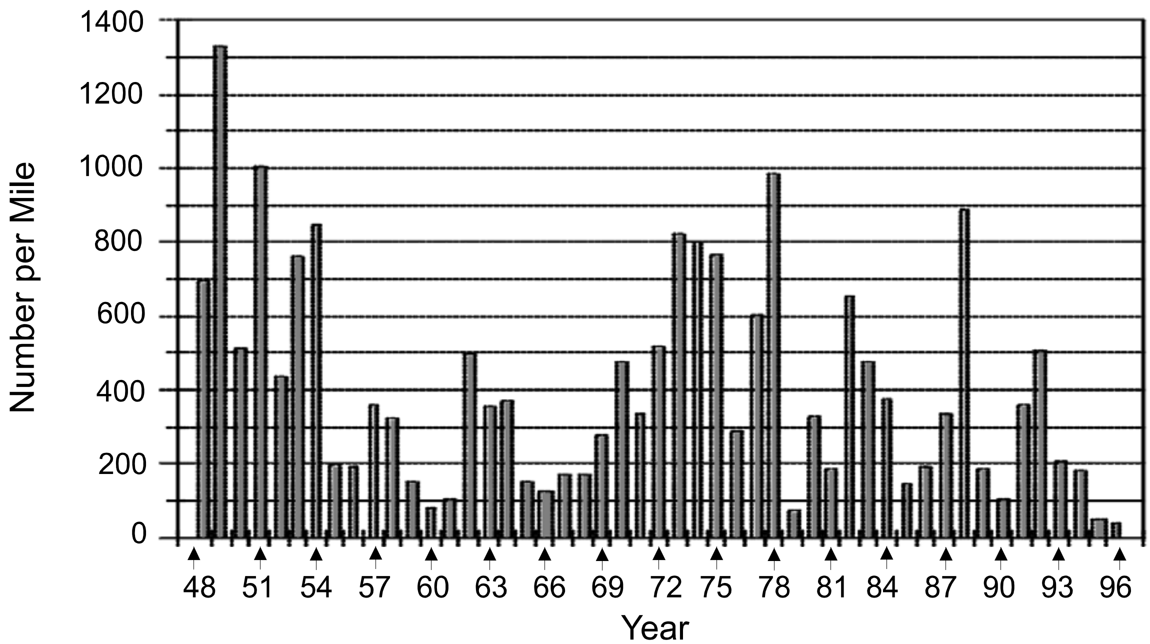


Figure 2.5. Tillamook Bay watershed peak count estimates for chum salmon. Source: TBNEP (1998).

diversions, loss of marsh and cedar boglands, loss of estuary complexity, urbanization, and other actions have probably had severe effects on chum salmon. The species in Oregon requires typical low gradient, gravel-rich, barrier-free freshwater habitats and productive estuaries (ODFW 1995).

2.7.5 Species Distribution

The observed decline in chum populations locally have been attributed to declines in the quality and quantity of spawning habitat and reduced egg survival (Michele Long, ODFW, pers. comm., June, 2001). ODFW mapped current chum distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Chum salmon use most of the mainstem Miami River, including the lower portions of the tributary streams (Figure 2.6). Only the highest elevations of the Miami River watershed are not utilized by chum salmon. The Miami River watershed provides a great deal of important habitat for this species. Most chum spawning in this river occurs between RM 1 and RM 7.

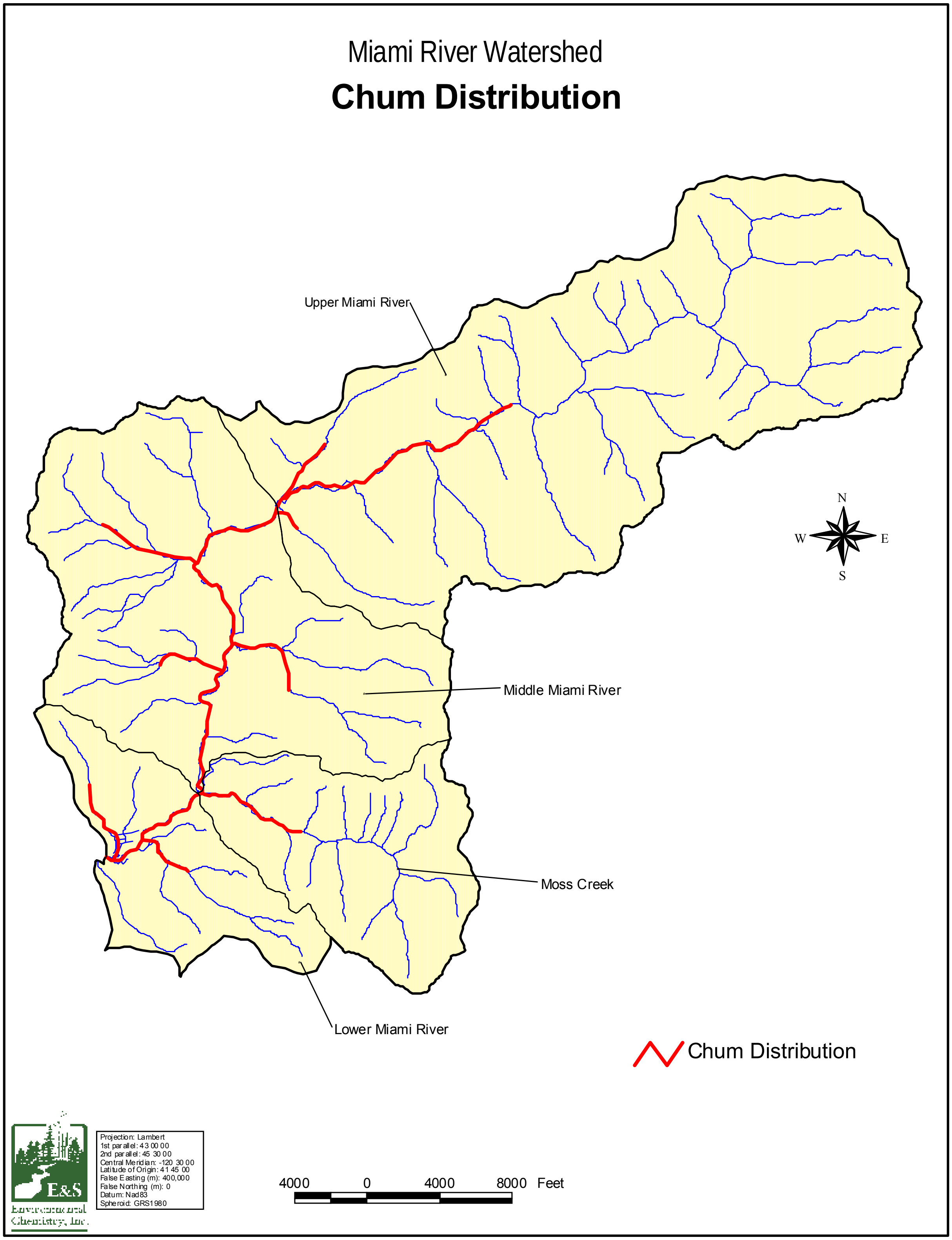


Figure 2.6. Chum distribution in the Miami River watershed (ODFW 2000)

2.7.6 Hatcheries

Oregon has never had a large chum salmon hatchery program, and there are currently no state hatchery programs for the species. One private hatchery has operated in the Nehalem estuary over the past few years. The objective at this hatchery has been to collect all returning hatchery adults, although some straying occurred. Chum salmon were probably impacted by coho salmon hatchery programs that released large numbers of hatchery smolts into estuaries used by rearing juvenile chum. Coho salmon juveniles have been shown to be a major predator on chum juveniles in the Northwest (Hargreaves and LeBrasseur 1986). Juvenile chum salmon may also be affected by large releases of fall chinook salmon hatchery fish, particularly presmolts, since fall chinook juveniles also rear in estuaries and may compete with chum juveniles (ODFW 1995).

Chum salmon populations in the Tillamook Watershed have not been supplemented by hatchery fish. Chum adults return to spawn at ages 2 to 7 with most returning at ages 3 to 5 (Emmett et al. 1991). 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. Recent habitat trend information for these areas is not available (TBNEP 1998).

2.8 Steelhead

2.8.1 Life History

The subspecies (*Oncorhynchus mykiss irideus*) includes a resident phenotype (rainbow trout) and an anadromous phenotype (coastal steelhead). Steelhead express a further array of life histories, including various freshwater and saltwater rearing strategies and various adult spawning migration strategies. Juvenile steelhead may rear one to four years in fresh water prior to their first migration to salt water. Saltwater residency may last one to three years. Adult steelhead may enter fresh water on spawning migrations year round if habitat is available for them, but generally spawn in the winter and spring. Both rainbow and steelhead may spawn more than once. Steelhead return to salt water between spawning runs.

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, including most of the Miami River watershed. Summer steelhead were introduced to the Basin in the early 1960s and are supported entirely by hatchery production (TBNEP 1998).

Although summer steelhead have been observed in the Miami River, most occur in the Wilson River and Trask River subbasins. Summer steelhead typically enter Tillamook Bay streams from April through July and hold in deep pools until they spawn the following winter. 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 (Emmett et al. 1991).

2.8.2 Listing Status (Source: http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm).

On March 19, 1998, NMFS determined that steelhead listing was not warranted for the Oregon Coast ESU. However, the ESU is designated as a candidate for listing due the fact 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 (ONRC et al. 1994) requested ESA protection for the winter runs of steelhead in the Miami, Kilchis, Wilson, and Trask Rivers. The ESU includes steelhead from Oregon coastal rivers between the Columbia River and Cape Blanco. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,604 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.8.3 Population Status

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 run 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 that the naturally-produced runs totaled only 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; TBNEP 1998).

The only information available for assessing trends in the abundance of steelhead runs to Tillamook Bay streams is angler salmon/steelhead report tags and holding pool counts for summer steelhead. The combined recreational catch of winter steelhead for all five subbasins and Tillamook Bay shows a declining trend since the early 1970s (Figure 2.7). As indicated in Figure 2.7, the recreational catch has declined from a high of more than 20,000 in 1970 to fewer than 2,000 in 1993. The trend in the combined catch reflects the trends seen in each of the individual subbasins.

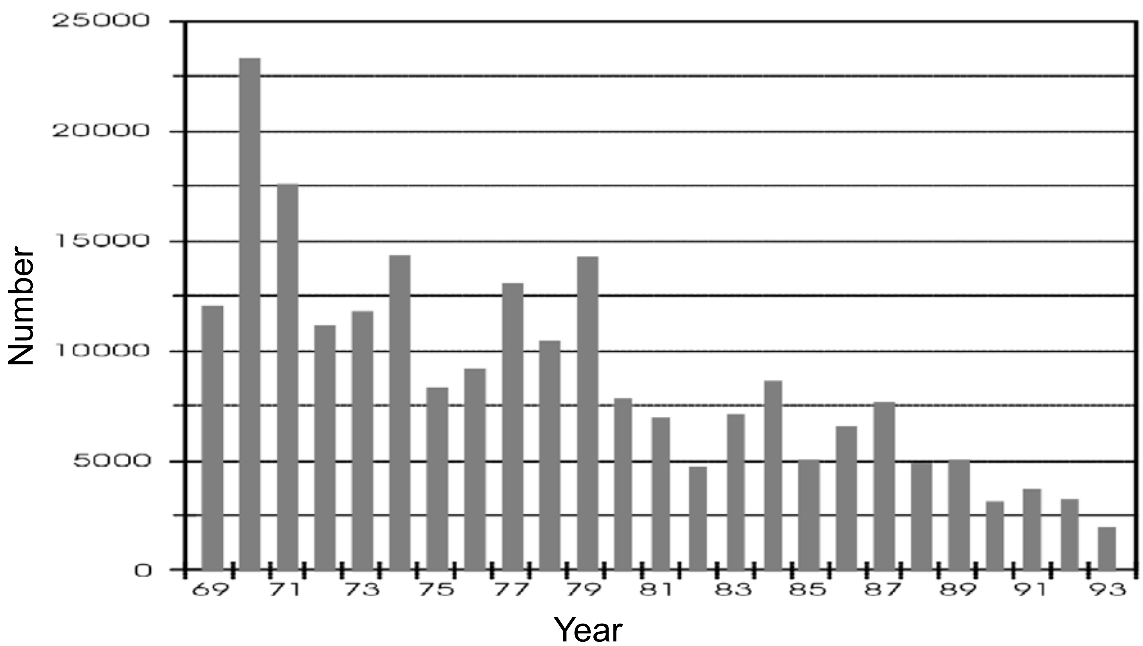


Figure 2.7. Tillamook Bay watershed sport catch of winter steelhead trout. Source: TBNWP (1998).

2.8.4 Factors Responsible for Decline

Coastal steelhead abundance follows a similar cycle in all populations from Puget Sound in Washington to California, indicating that factors common to all populations influence trends. The most probable factor responsible for this cycle is ocean condition. Ocean productivity is recognized to undergo long-term cycles that include periods that are relatively favorable or unfavorable to the survival of salmonids. This cycle appears to be a natural process that cannot be affected by management actions. The ocean productivity cycle appears to have been unfavorable for steelhead recently and all steelhead population abundance trends have been correspondingly low (ODFW 1995).

Steelhead and rainbow populations have also been affected by freshwater habitat degradation. Most coastal salmonid freshwater habitats were historically coniferous temperate rain forest ecosystems. Stream systems were structurally complex, with large in-stream wood, flood plains, beaver ponds, braided channels, and coastal marshes and bogs. Human activities have altered these ecosystems, particularly by reducing their complexity and removing components that were essential to steelhead and rainbow trout production. Logging and road construction in the Coast Range and Cascade Mountains has had the most widespread impact on coastal steelhead, and has affected most populations. Most habitat impacts are variable in different basins and are not well understood for the Miami River specifically.

2.8.5 Species Distribution

ODFW mapped current steelhead distribution by attributing 1:100,000 stream coverages based on survey data, and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. Theses coverages are scheduled to be updated every two years, and are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Winter steelhead use the entire Miami River watershed. They are found along the mainstem to the headwaters and in all of the major tributary systems (Figure 2.8). Winter steelhead require structurally complex streams with large in-stream wood, flood plains, beaver ponds, braided channels, and coastal marshes and bogs. The upper Miami mainstem, from the confluence with Prouty Creek (RM 5.5) upstream to RM 11, provides moderate to low gradient forested habitat that is suitable for winter steelhead spawning and rearing.

Summer steelhead occur only sporadically in the lower Miami River watershed. This watershed does not constitute important summer steelhead habitat.

2.8.6 Hatcheries

Coastal steelhead hatchery programs are present along the coast and in the lower Columbia and Willamette basins. These programs historically depended on two broodstocks. The Alsea winter steelhead hatchery stock was founded from wild steelhead in the Alsea River on the

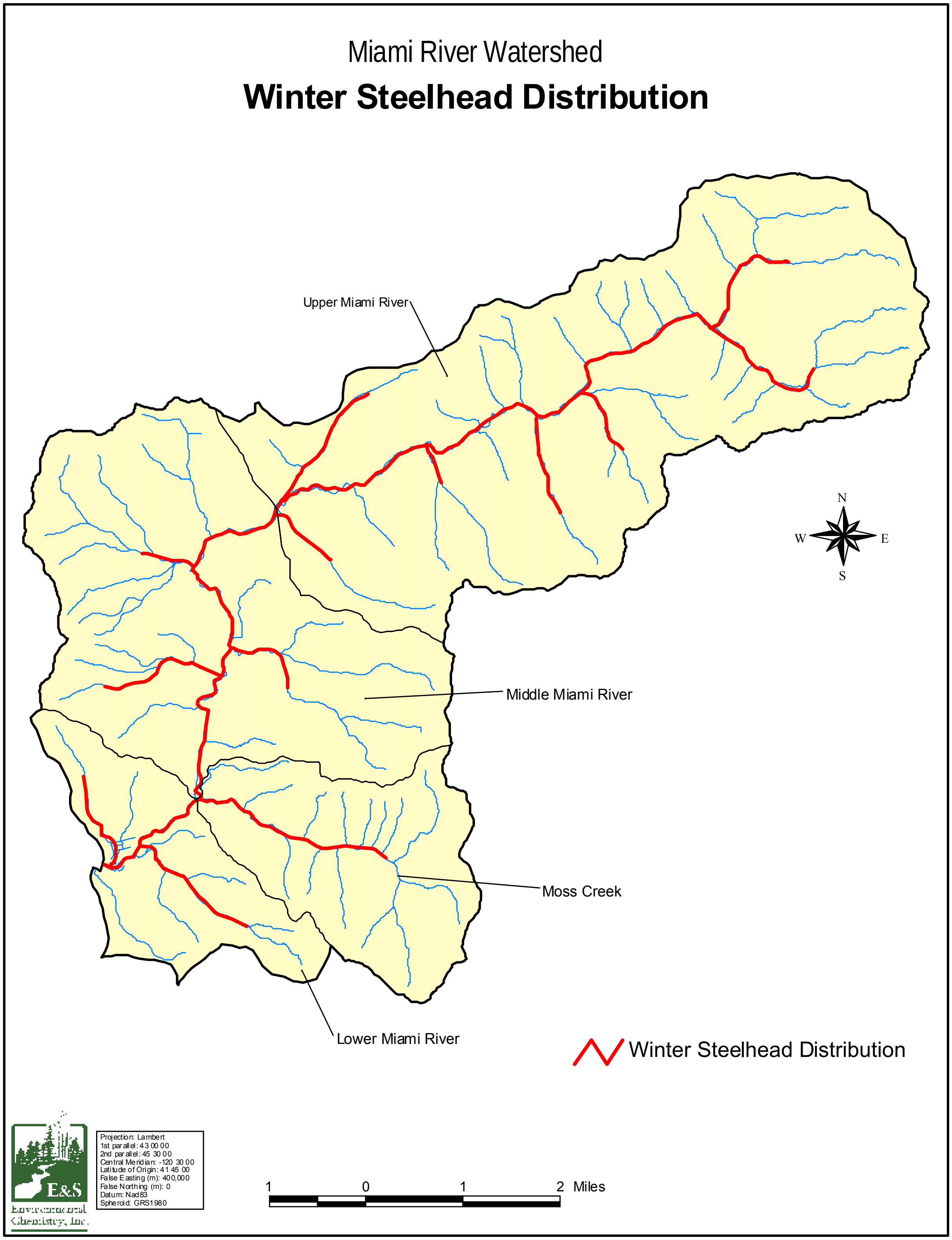


Figure 2.8. Winter steelhead distribution in the Miami River watershed. (ODFW 2000)

mid-coast. This stock has been outplanted into most coastal basins. In spite of this widespread outplanting of a single broodstock, Oregon's wild coastal steelhead populations have not been "homogenized" like those described by Reisenbichler and Phelps (1989) in Puget Sound. This is demonstrated by the high level of genetic variation that is still present among steelhead populations along the Oregon coast (Hatch 1990, Reisenbichler et al. 1992). Alsea steelhead are now being planted in fewer locations and local broodstocks are being developed in many of the basins (ODFW 1995).

Winter steelhead were previously planted in the Miami River. This practice was discontinued in about 1994 (Keith Brown, ODFW, pers. comm., September, 2001). There is no evidence to suggest that hatchery programs have had a significant impact on Miami River stocks.

CHAPTER 3. AQUATIC AND RIPARIAN HABITATS

3.1 Introduction

Distribution and abundance of salmonids within the watershed varies with habitat conditions such as substrate and pool frequency, gradient, access, and biological factors such as food distribution (i.e. insects and algae). In addition, salmonids have complex life histories and use different portions of the watershed during different parts of their life cycle. For example, salmonids need gravel substrates for spawning, but may move to different stream segments during rearing. There are also differences among salmonid species in their timing and extent of habitat utilization. The interactions of these factors in space and time make it difficult to identify the specific watershed components that most strongly affect salmonid populations. Consequently, entire watersheds must be managed to maintain fish habitats, and not just individual components (Garono and Brophy 1999).

Understanding the spatial and temporal distribution of key aquatic habitat components is the first step in learning to maintain conditions suitable to sustain salmonid populations. These components must then be linked to larger scale watershed processes that may control them. For example, a stream that lacks sufficient large woody debris (LWD) often has poor LWD recruitment potential in the riparian areas of that stream. By identifying this linkage, riparian areas can be managed to include more conifers to increase LWD recruitment potential. Also, high stream temperatures can often be linked to lack of shade as a result of poorly vegetated riparian corridors. By linking actual conditions to current watershed-level processes, land managers can better understand how to manage the resources to maintain these key aquatic habitat components.

Healthy populations of anadromous salmonids are generally associated with the following freshwater habitat characteristics:

- cool, clean, well oxygenated water;
- unobstructed access to spawning grounds;
- clean, stable spawning gravel;
- winter refuge habitat for juveniles;
- complex stream channel structure with an appropriate mixture of riffles, pools, and glides;
- deep pools;
- stream channels with an abundant supply of large woody debris;

- abundant food supply;
- adequate summer stream flows; and
- diverse, well-established riparian community.

Many of these habitat elements as well as some additional species-specific habitat criteria have been evaluated in the Tillamook Basin during the last six years as part of the ODFW Aquatic Inventory Project. Although the project is not yet complete, these surveys provide the best source of information for assessing the present status of the freshwater habitat.

A streambank erosion control project was implemented in Moss Creek, beginning in 1986 (Tillamook County Soil and Water Conservation District 1996). A variety of treatment measures were implemented at multiple sites in order to reduce streambank erosion, improve water quality, and improve salmonid habitat. Specific projects involved construction of boulder deflectors, jetties, and rock diversions; placement and stabilization of in-stream log structures; planting conifers and willows in the riparian zone; and installing fencing to exclude livestock from riparian areas.

3.2 Aquatic Habitat Data

To assess current habitat conditions within the Miami River watershed we have compiled fish habitat survey data collected according to the ODFW protocol (Moore et al. 1997). Stream survey data provide a snapshot in time of stream conditions. However, streams are dynamic and channel conditions may change drastically from year to year, depending on climatic conditions. Nevertheless, these data are useful in describing the current status or suggesting the existence of trends in habitat conditions that may be linked to larger watershed processes. Through development of an understanding of habitat distribution patterns, land managers can identify and address problem areas.

To interpret the habitat survey data, ODFW has established statewide benchmark values as guidelines for an initial evaluation of habitat quality (Table 3.1). The benchmarks rate conditions as desirable, moderate, or undesirable in relation to the natural regime of these streams. These values depend upon climate, geology, vegetation and disturbance history, and can help to identify patterns in habitat features that can lead to a better understanding of the effects of watershed processes on the current conditions of the stream channel.

Table 3.1. Stream channel habitat benchmarks. Source (except LWD Recruit. Potential): ODFW 1995.

Parameter	Subfactor	Units	Good	Fair	Poor
Pool area		% of channel area	$35	>10 and <35	#10
Pool frequency		# of channel widths	#8	> 8 and <20	$20
Residual pool depth	gradient <3% or <7m wide	meters	$0.5	>0.2 and <0.5	#0.2
	gradient >3% or >7m wide	meters	$1.0	>0.5 and <1.0	#0.5
Riffle width/depth ratio	gradient <3%	ratio	#10	>10 and <30	$30
Silt/sand/organic matter		% of area	#10	>10 and <25	$25
Gravel available		% of area	$35	>15 and <35	#15
Shade	ACW <12m wide	% for reach	$70	>50 and <70	#50
	ACW >12m wide	% for reach	$60	>40 and < 60	#40
LWD pieces		# pieces/100m	$20	>10 and <20	#10
LWD volume		cubic m/100m	$30	>20 and <30	#20
LWD key (>50 m dia. and > ACW long)		# pieces/100m	$3	>1 and <3	#1
LWD recruit. potential* (Uses 3 subfactors)	1) age/size	cm diameter	old (>90 cm)	medium (< 50 cm)	Young (maj. small)
	2) density	% crown closure	dense (>67%)		sparse (67%)
	3) species	species	conifer (>70%)	mixed	deciduous (70%)

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

Since 1996, 17 streams and river reaches have been surveyed in the Miami River watershed, covering the entire mainstem plus some tributary streams in the Lower and Middle Miami River subwatersheds (Figure 3.1, Table 3.2). The large flood event of 1996 most likely altered LWD conditions in the watershed and probably introduced some new LWD to the stream network. High peak flows in 1998 and 1999 further altered LWD conditions in the watershed. However, stream channels still lack LWD in general. The condition of LWD in the system is dynamic, and while watershed-scale assessments can provide information useful for prioritizing restoration activities, all sites should be field- verified before specific restoration actions are planned.

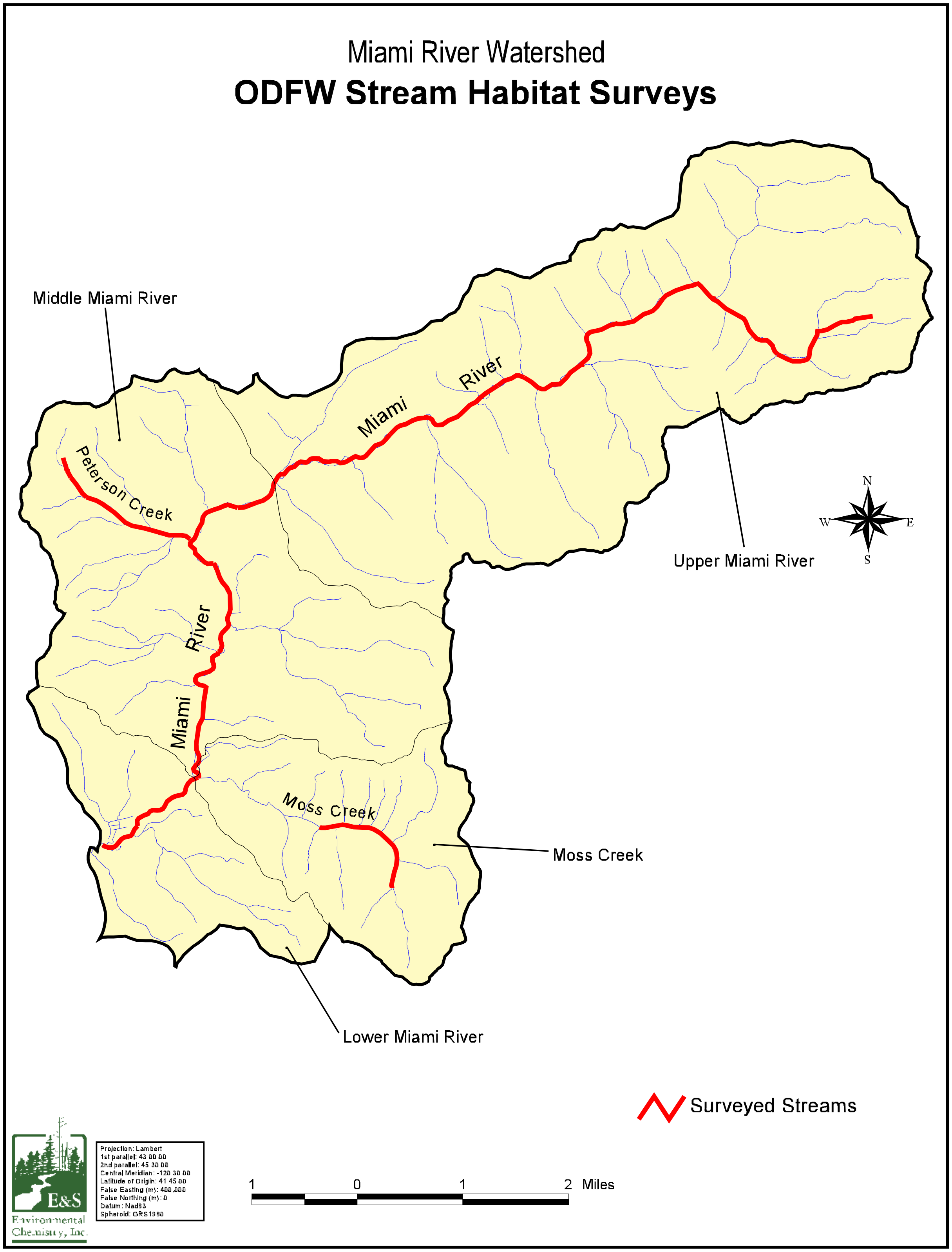


Figure 3.1. Streams surveyed for habitat conditions by ODFW.

Table 3.2. Stream morphology and substrate conditions in the Miami River watershed as compared to ODFW benchmark values. Benchmark values for stream habitat conditions have been provided in Table 3.1. Data were collected by ODFW. The Miami River flows through all four subwatersheds. Moss Creek is a subwatershed of the Miami and Peterson Creek is a drainage basin in the Middle Miami River subwatershed.

Stream	Reach*	Stream Miles	Gradient (%)	Pool Frequency (Channel Width Between Pools)	Percent Pools	Residual Pool Depth (m)	Gravel in Riffles (%area)
Miami River	1	0.3	0.1	47.8	7.6	0.8	11.0
	2	0.9	0.1	4.5	49.5	0.9	27.0
	3	1.6	0.2	4.9	38.7	1.3	29.0
	4	1.1	0.4	4.1	32.4	0.8	25.0
	5	0.9	0.2	0.0	0.0	0.0	0.0
	6	0.3	0.3	11.3	21.9	1.2	27.0
	7	0.1	0.9	0.0	0.0	0.0	0.0
	8	0.4	0.5	8.8	41.3	1.0	23.0
	9	1.4	0.5	2.2	43.4	0.8	38.0
	10	0.7	0.7	2.5	42.6	0.8	34.0
	11	0.6	0.8	1.8	37.5	0.9	31.0
	12	3.7	1.8	5.7	20.9	0.6	19.0
	13	1.7	13.5	19.8	9.2	0.5	17.0
Moss Creek	1	1.5	4.4	33.9	6.8	0.6	25.0
Peterson Creek	1	1.2	2.6	11.0	27.5	0.5	54.0
	2	0.3	9.2	0.0	0.0	0.0	42.0
	3	0.3	14.8	0.0	0.0	0.0	43.0

(light grey) = Desirable; (dark grey) = Undesirable; (white) = Moderate

* Locations of the reaches surveyed by ODFW are shown on Figure 3.1. The lower reach numbers correspond with the lower sections of surveyed streams.

3.2.1 Stream Morphology and Substrates

Stream morphology describes the physical state of the stream, including features such as channel width and depth, pool frequency, and pool area (Garono and Brophy 1999). Pools are important features for salmonids, providing refugia and feeding areas. Substrate type is also an important channel feature since salmonids use gravel beds for spawning. These gravel beds can be buried by heavy sedimentation, resulting in loss of spawning areas as well as reduced invertebrate habitat. For streams that were surveyed, stream morphology and substrates were compared against ODFW benchmarks (Table 3.1) to evaluate current habitat conditions.

Of the streams surveyed, 76% showed pool frequency in the moderate category and only 1 of 17 surveyed reaches was rated as desirable. Only 12% of the surveyed stream reaches were in the undesirable category. The surveyed reaches were nearly evenly split among the three categories for percent of area of the stream reach in pools, with a slightly lower percentage of the reaches rated as desirable (35%).

Pool frequency was generally rated as moderate. The surveyed reaches showed more variability in their ratings for percent pools, residual pool depth, and gravel in riffles, however. Residual pool depth showed the best conditions, among the stream morphology and substrate characteristics, with 59% rated as desirable. There was not a consistent pattern among the various subwatersheds (Table 3.2).

Gravel beds are important channel features since they provide spawning areas for salmonids. Gravel conditions in riffles demonstrated moderate to desirable conditions in nearly two-thirds of the reaches surveyed (Table 3.2). There was an approximately equal number of reaches classified in the desirable and undesirable categories. The fact that the majority of reaches surveyed throughout the Miami River watershed had moderate gravel conditions suggests a need for improvement.

3.2.2 Large Woody Debris

Large woody debris is an important feature that adds to the complexity of the stream channel. LWD in the stream provides cover, produces and maintains pool habitat, creates surface turbulence, and retains a small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (Bischoff et al. 2000; BLM 1996). LWD is most abundant in intermediate sized channels in third- and fourth-order streams. In fifth-order and larger streams, LWD is less likely to remain stable in the channel. In wide channels, LWD is more likely to be found along the edge of the channel.

In general, LWD conditions in the surveyed streams were poor. In particular, the volume and density of key pieces of LWD were predominantly rated as undesirable (84% and 68%, respectively). In only 16% of the surveyed stream reaches was either the volume or density of key pieces rated as desirable (Table 3.3). Conditions for conifer LWD were slightly better in the Lower Miami River than in the surveyed reaches of the Middle or Upper Miami River subwatershed. Riparian conditions almost uniformly demonstrated undesirable conditions, with all stream reaches surveyed lacking sufficient densities of conifers in the riparian zones (Table 3.4). Similarly, many of the streams showed poor LWD recruitment potential (Table 3.5, 3.6).

Table 3.3. Large woody debris conditions in the Miami River watershed as compared to ODFW habitat benchmark values. Data were collected by ODFW. The Miami River flows through all four subwatersheds. Moss Creek is a subwatershed of the Miami and Peterson Creek is a drainage basin in the Middle Miami River subwatershed.

Stream	Reach	Stream Miles	Gradient (%)	Woody Debris		
				# Pieces/ 100m	Vol. (m^3/100m)	# Key Pieces / 100m
Miami River	1	0.3	0.1	19.6	9.8	0.40
	2	0.9	0.1	9.4	5.2	0.40
	3	1.6	0.2	7.1	8.6	0.10
	4	1.1	0.4	6.5	5.5	0.10
	5	0.9	0.2	0.0	0.0	0.00
	6	0.3	0.3	2.0	1.8	0.00
	7	0.1	0.9	0.0	0.0	0.00
	8	0.4	0.5	1.5	0.4	0.00
	9	1.4	0.5	11.5	12.5	0.00
	10	0.7	0.7	12.0	16.7	0.00
	11	0.6	0.8	11.9	14.2	0.00
	12	3.7	1.8	6.9	8.1	0.00
	13	1.7	13.5	34.1	58.4	0.00
Moss Creek	1	1.5	4.4	7.0	17.5	0.50
Peterson Creek	1	1.2	2.6	10.0	11.2	0.00
	2	0.3	9.2	24.5	25.4	0.00
	3	0.3	14.8	30.9	68.9	0.00
	= Desirable		= Undesirable		= Moderate	

Table 3.4. Riparian conifer conditions in the Miami River watershed as compared to ODFW habitat benchmark values. Benchmark values for stream habitat conditions have been provided in Table 3.1. Data were collected by ODFW. The Miami River flows through all four subwatersheds. Moss Creek is a subwatershed of the Miami and Peterson Creek is a drainage basin in the Middle Miami River subwatershed.

Stream	Reach	Stream Miles	Gradient (%)	Width (m)	Shade (%)	# Conifers > 20" dbh per 1,000 ft stream length	# Conifers > 35" in dbh per 1,000 ft stream length
Miami River	1	0.3	0.1	13.2	36.0	0.0	0.0
	2	0.9	0.1	11.7	61.0	0.0	0.0
	3	1.6	0.2	12.7	45.0	0.0	0.0
	4	1.1	0.4	10.6	43.0	0.0	0.0
	5	0.9	0.2	0.0	100.0	0.0	0.0
	6	0.3	0.3	11.2	36.0	0.0	0.0
	7	0.1	0.9	0.0	100.0	0.0	0.0
	8	0.4	0.5	12.7	70.0	0.0	0.0
	9	1.4	0.5	8.4	64.0	0.0	0.0
	10	0.7	0.7	9.1	75.0	0.0	0.0
	11	0.6	0.8	7.6	71.0	42.2	0.0
	12	3.7	1.8	7.1	92.0	30.1	24.1
	13	1.7	13.5	3.3	99.0	0.0	0.0
Moss Creek	1	1.5	4.4	4.0	81.0	0.0	0.0
Peterson Creek	1	1.2	2.6	3.7	80.0	0.0	0.0
	2	0.3	9.2	1.5	95.0	0.0	0.0
	3	0.3	14.8	1.1	91.0	60.3	0.0

[light grey] = Desirable; [dark grey] = Undesirable; [white] = Moderate

Table 3.5 Habitat benchmark values for large woody debris conditions. Benchmark values for stream habitat conditions have been provided in Table 3.1. Data were collected by ODFW.

Recruitment Potential	Stand Density*	Description
Low	Dense	Small trees of all species (<12" dbh**)
	Sparse	Small trees of all species (<12" dbh), and sparse medium-sized hardwoods (12" - 24" dbh)
Moderate	Dense	Medium-sized conifers, hardwoods, and mixed conifers/hardwoods (12" - 24" dbh)
	Sparse	Large conifers and mixed large conifers/hardwoods (>24" dbh); Medium-sized conifers, mixed medium conifers/hardwoods (12" - 24")
High	Dense	Large conifers and mixed large conifers/hardwoods (>24"

*Dense: <1/3 of ground exposed; sparse: > 1/3 of ground exposed
**Diameter breast-height

Table 3.6 Large woody debris recruitment potential in the riparian zone. RA1 and RA2 widths based on channel constrainment and ecoregion (WPN 1999).

Subwatershed	Stream Length (mi)	RA1* (%)			RA2* (%)			Overall Average (%)		
		Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Lower Miami River	12	52	48	0	51	49	0	51	49	0
Middle Miami River	28	69	31	0	68	32	0	69	31	0
Moss Creek	13	79	21	0	79	21	0	79	21	0
Upper Miami River	37	83	17	0	65	35	0	74	26	0
Watershed Average		71	29	0	66	34	0	68	32	0

* RA1 is the riparian zone adjacent to the stream, on both sides. RA2 is the riparian buffer zone adjacent to the RA1 zone on both sides of the stream.

3.2.3 Large Woody Debris Recruitment Potential

Recruitment potential of LWD from the riparian zone was identified based on the size and species of trees in the riparian zone and their distance from the streambank, according to the OWEB methodology. It provides a coarse-screening of the overall condition of LWD recruitment potential throughout the watershed. Riparian vegetation was categorized as having a high, moderate, or low potential for large woody debris recruitment. Vegetation classes defined as coniferous or mixed in the large class (>24 inch dbh) had a high potential for LWD recruitment. Coniferous or mixed vegetation in the medium size class (12-24 inch dbh), and hardwoods in the medium to large class, had moderate potential for LWD recruitment (Table 3.6).

In general, the potential for LWD recruitment in the Miami River watershed was poor (Figure 3.2). None of the riparian areas in the watershed demonstrated a high potential to contribute LWD to the stream channel. In all of the subwatersheds, the majority of LWD recruitment potential was low (Table 3.6). The lack of large conifers (>24" dbh) in this watershed is likely a result of the Tillamook Burn and historic vegetation removal along the riparian corridor.

It should be noted that not all areas would contribute large amounts of LWD to the stream system even if there was a high density of large conifers. In general, large streams (i.e. >4th-order) low in the watershed are not likely to contribute as much LWD as smaller streams in the middle portion of the watershed. This is because large streams often are in flat valley bottoms with wide gravel bars along the banks, whereas in the upper part of the watershed hillslopes are

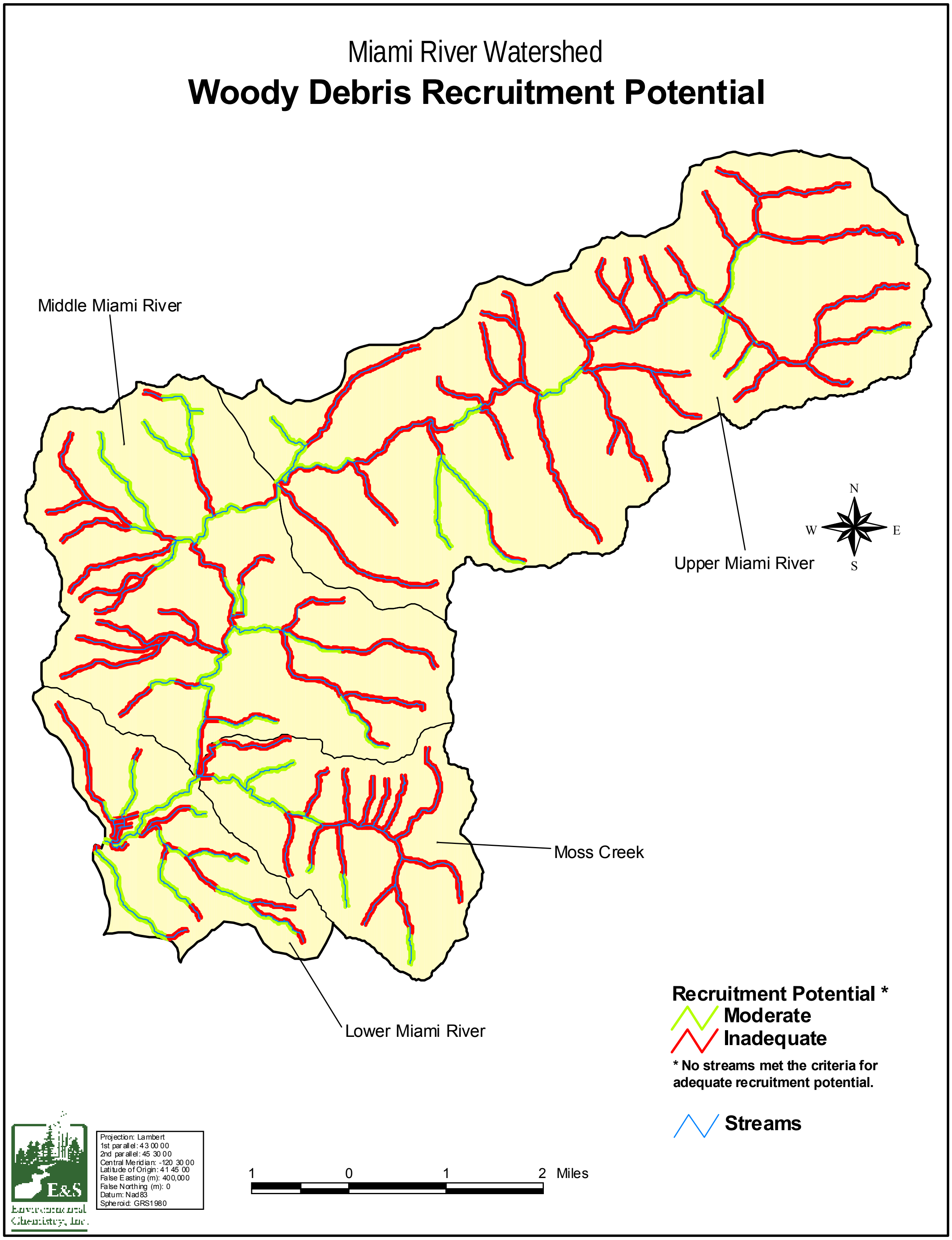


Figure 3.2. Woody debris recruitment potential in the Miami River watershed. Data were developed from aerial photo interpretation conducted by E&S Environmental Chemistry, Inc.

usually steeper, channels straighter, and banks narrower. LWD is less likely to stabilize in the lower reaches of the river system because the channel is often wider than the LWD pieces are long (WPN 1999). However, the lower river serves an important function in transporting LWD to the estuary, where it contributes to estuarine habitat complexity.

3.3 Riparian Conditions

The riparian zone is the area along streams, rivers and other water bodies where there is direct interaction between the aquatic and terrestrial ecosystems. The riparian zone ecosystem is one of the most highly valued and highly threatened in the United States (Johnson and McCormick 1979, National Research Council 1995 in Kauffman et al. 1997). Riparian vegetation is an important element of a healthy stream system. It provides bank stability, controls erosion, moderates water temperature, provides food for aquatic organisms and large woody debris to increase aquatic habitat diversity, filters surface runoff to reduce the amount of sediments and pollutants that enter the stream, provides wildlife habitat, dissipates flow of energy, and stores water during floods (Bischoff et al. 2000). Natural and human degradation of riparian zones diminishes their ability to provide these critical ecosystem functions.

The USDA Farm Service Agency in Tillamook provided monochromatic aerial photos of the Miami River watershed. The aerial photos were taken in 1990 at a scale of 1:7,920. Mylar overlays of the stream network were generated with the GIS. Riparian vegetation and shade conditions were interpreted from the photos, recorded on the overlays, and then digitized into the GIS by E&S.

Riparian vegetation frequently occurs in several zones parallel to the stream bank. For example, often a band of young hardwoods lines the stream bank, behind which is a zone of conifers. Consequently, riparian vegetation was assessed for two zones parallel to and on both sides of the stream bank (RA1 and RA2, Table 3.6). RA1 is the zone closest to the stream and RA2 the zone adjacent to RA1 and further away from the stream. Although LWD may theoretically reach the stream from a distance of a site potential tree height, the majority of functional wood has been found to come from within 100 feet of the stream. The overall width of these two zones was therefore set at 100 feet, according to OWEB recommendations (McDade et al 1990, WPN 1999).

Shade conditions in the streams surveyed were generally rated as desirable in the Upper Miami River and Moss Creek subwatersheds (Table 3.4). However, ODEQ's latest reports, prepared in conjunction with the TMDL process, indicate shade to be deficient throughout the watershed. It is possible, perhaps likely, that shade conditions throughout the upland forest, not just within the riparian area, have a significant impact on stream temperature. In addition, riparian conifer conditions were mixed in most reaches surveyed in the Lower and Middle Miami River, with no desirable reaches in the Lower Miami River and 6 of 10 survey reaches rated as desirable in the Middle Miami River. These results suggest that much of the shading in the riparian zone of the watershed is provided by hardwood species such as alder or maple. These relatively short-lived hardwoods do not contribute high quality LWD to the stream system.

Riparian vegetation provides shade and insulation that helps moderate stream temperatures. While shade will not actually cool a stream, riparian vegetation blocks solar radiation before it reaches the stream and prevents the stream from heating (Bischoff et al. 2000, Beschta 1997, Boyd and Sturdevant 1997, Beschta et al. 1987). The shading ability of the riparian zone is determined by the quality and quantity of vegetation present. The wider the riparian zone and the taller and more dense the vegetation, the better the shading ability (Beschta 1997, Boyd and Sturdevant 1997). Current shade conditions for the Miami River watershed were estimated from the aerial photo interpretation.

Results from our air-photo analysis of stream shading yielded similar results to the stream reach surveys of ODFW. Stream shading conditions were generally high across the watershed (Figure 3.3, Table 3.7). Shade conditions were high for at least 66% of the stream length in all of the subwatersheds. The Lower Miami River was the only subwatershed for which $79% of

Table 3.7. Current stream shading conditions in the Miami River watershed, based on aerial photo interpretation conducted by E&S.

Subwatershed	Total Stream mi	% Low	% Medium	% High
Lower Miami River	12	20	14	66
Middle Miami River	28	10	4	86
Moss Creek	13	5	15	79
Upper Miami River	37	1	7	92
Watershed Average		9	10	81

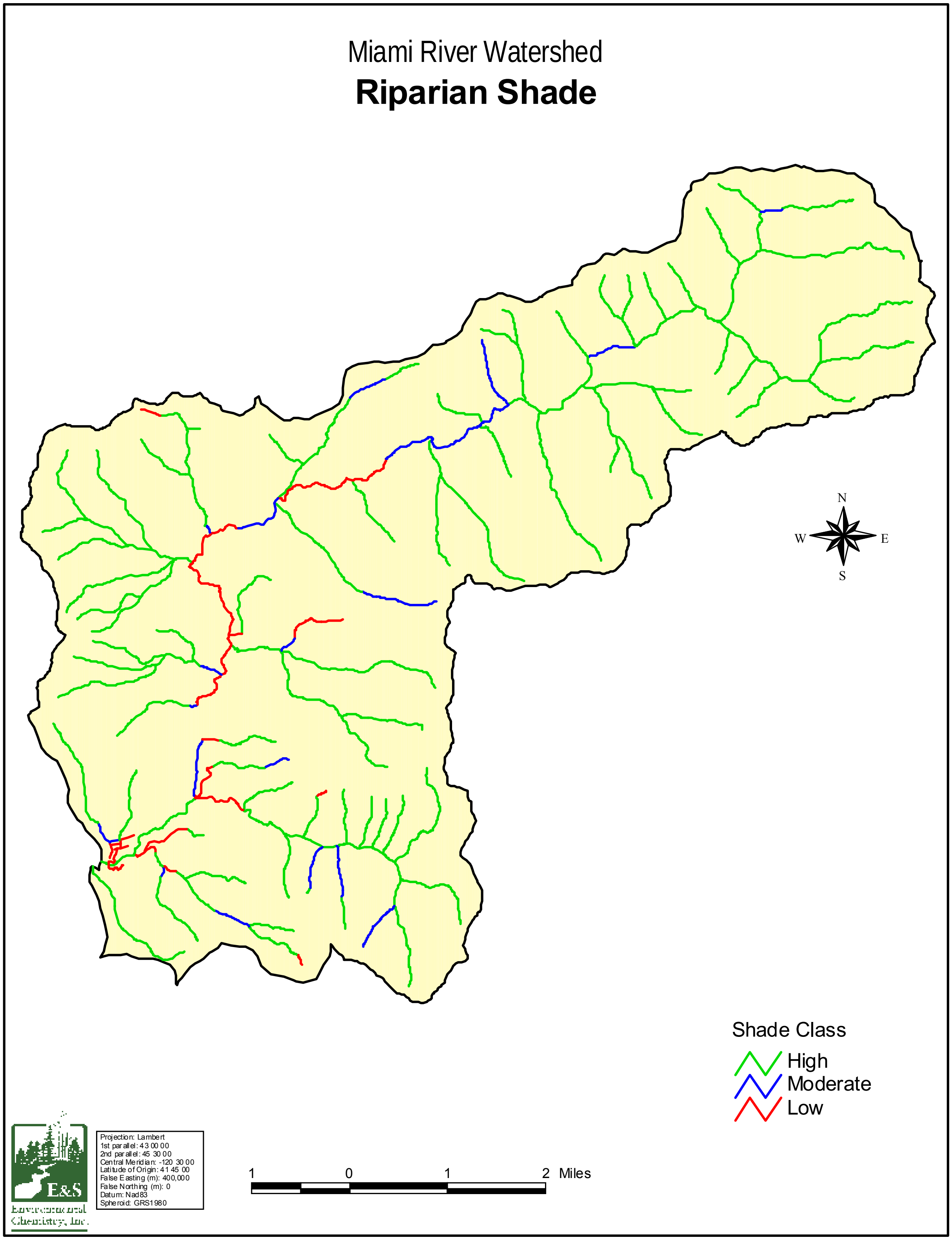


Figure 3.3. Riparian shade conditions in the Miami River watershed. Data were developed from aerial photo interpretation conducted by E&S Environmental Chemistry, Inc.

the stream was not in the high shade category. Many of the areas of low shading were located along the mainstem in the Middle Miami River subwatershed, and secondarily along the mainstem and several tributaries in the Lower Miami River subwatershed (Figure 3.3).

3.4 Fish Passage Barriers

Stream channels are often blocked by natural barriers, such as waterfalls, or by human-caused barriers, especially poorly designed culverts at road crossings. This has resulted in significant loss of fish access to suitable habitat. Anadromous fish migrate upstream and downstream in search of food, habitat, shelter, spawning beds, and better water quality. Fish populations can be significantly limited if they lose access to key habitat areas. As many as 75% of culverts in some forested drainages are either impediments or outright blockages to fish passage, based on surveys completed in Washington state (Conroy, 1997). Surveys of county and state roads in Oregon have found hundreds of culverts that at least partially block fish passage. Potential effects from the loss of fish passage include loss of genetic diversity by isolation of reaches, loss of range for juvenile anadromous and resident fish, and loss of resident fish from extreme flood or drought events (prevents return).

3.4.1 Culverts

Culverts can pose several types of problems for fish passage, including excessive height above the downstream pool, excessive water velocity, insufficient water depth in culvert, disorienting flow patterns, and lack of resting pools between culverts. Culverts can also limit fish species only during certain parts of their life cycles. For example, a culvert may be passable to larger adult anadromous fish and not passable to juveniles. Culverts may also act as passage barriers only during particular environmental conditions, such as high flow or low flow events. In addition, damaged culverts can directly harm or kill fish due to contact with jagged metal edges. In addition to limiting fish passage, culverts can also affect materials transport. In particular, culverts can limit the recruitment of gravel and LWD from upper to lower reaches. Because of the variety of potential effects, it is important to understand the interactions of habitat conditions and life stage for anadromous fish, and how these interactions are affected by culverts.

Less than one fourth of the total 100 road-stream crossings in the Miami River watershed have been surveyed for potential fish passage barriers and 43% of those surveyed were judged to be impassable (Figure 3.4, Table 3.8). The Miami River watershed has an average stream crossing density of 2.7 stream crossings per square mile. Stream crossing densities were highest in the Moss Creek and Lower Miami River subwatersheds (4.6 crossings/mi^2 each). All subwatersheds were found to have at least one impassable culvert.

Table 3.8. Culverts and road/stream crossings in the Miami River watershed. Road/stream crossings were generated using GIS. Culvert data were provided by ODFW.

Subwatershed	Watershed Area (sq. mi.)	# Surveyed Culverts	# Impassable Culverts	Road-Stream Crossings	
				#	#/mi^2
Lower Miami River	3.9	11	5	18	4.6
Middle Miami River	11.0	5	2	32	2.9
Moss Creek	4.6	6	2	21	4.6
Upper Miami River	17.2	1	1	29	1.7
Total	36.7	23	10	100	2.7

3.4.2 Natural Barriers

One natural fish passage barrier was identified in the Miami River watershed by ODFW. There is a waterfall near the headwater, but it has a fishway. Both coho and winter steelhead have been found above this falls, illustrating that it is not a complete fish passage barrier (Figure 3.4).

3.5 Channel Modifications

In-channel structures and activities such as dams, dredging or filling can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream channel. These changes can ultimately alter community composition of in-stream aquatic biota. Identification of channel modification activities can help in the determination of the likely effects of anthropogenic channel disturbances on channel morphology, aquatic habitat, and hydrologic functioning.

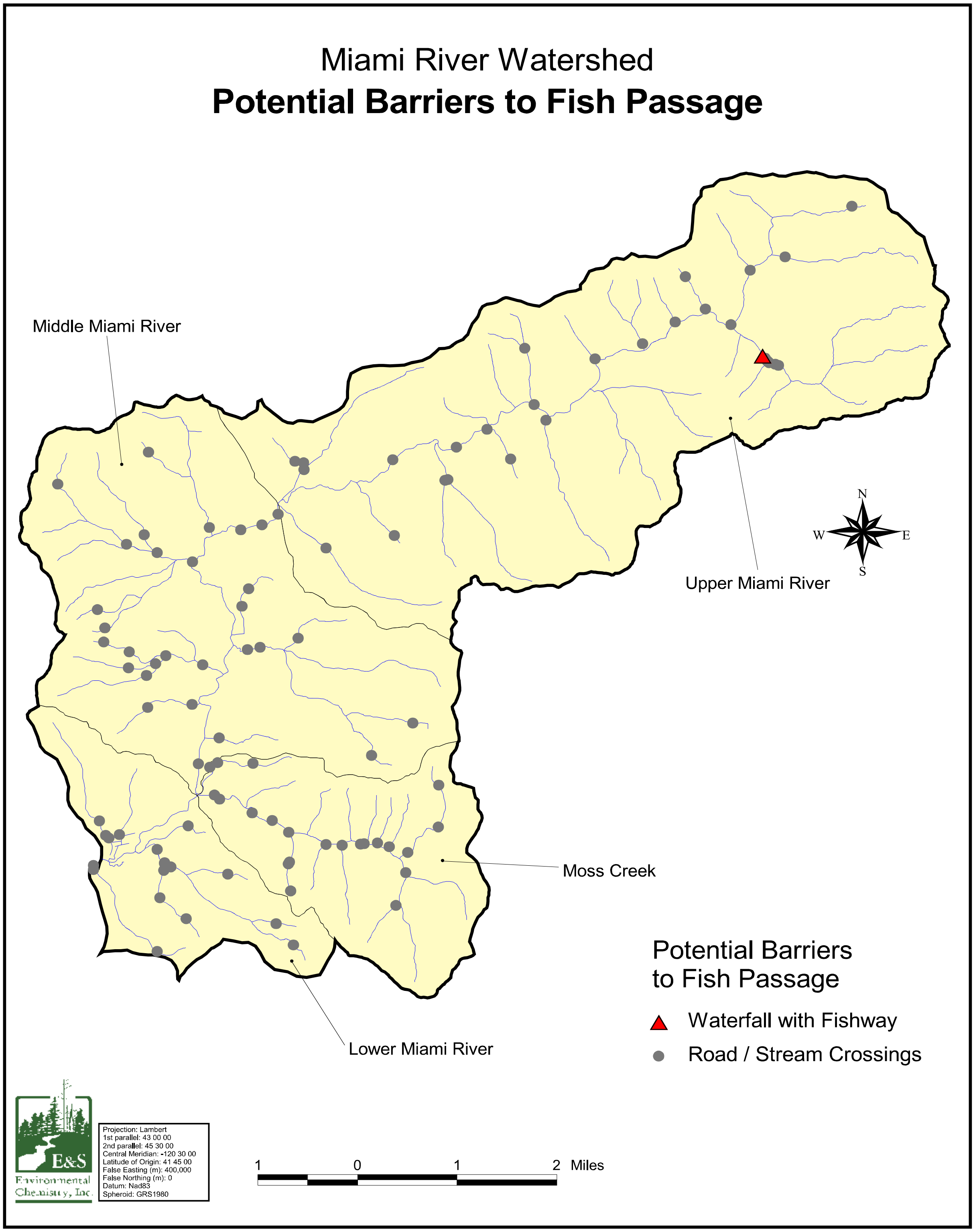


Figure 3.4. Road/stream crossings and known fish passage barriers in the Miami River watershed. Road/stream crossings were generated using GIS. Culvert data were provided by ODFW.

The present condition of freshwater habitat in the Miami River Watershed has been heavily influenced by human activities and natural phenomena that have occurred over an extended period of time. Several events and practices have severely disturbed the watershed.

3.5.1 Channelization, Diking, and Dredging

The Army Corps of Engineers (ACOE) was historically active in waterway modification projects in Tillamook Bay. From the mid-1890s to the mid-1970s, the ACOE performed maintenance dredging of the bay and snag clearing in the bay and lower river reaches for navigation purposes. Over time, changes in economic activity and improved ground transportation reduced the dependence of local commerce on water transportation and, in turn, the need for dredging.

There are special potential problems associated with dredging in estuaries and tidal river reaches. Waterway modifications in these areas may change local tidal currents or river flow patterns and, in turn, change sediment deposition, erosional processes, and vegetation communities. Damages from wave action may increase during storm events at high tides in deeper dredged waters, and the extent of the freshwater/saline water interface may shift in estuaries and river deltas, affecting agricultural or municipal water intakes, fisheries, and natural sedimentation processes (TBNEP 1998). Dredging can also simplify the physical estuary and river bed structure, thereby reducing microhabitat diversity.

Disconnecting the floodplain from the river can lead to reduced physical complexity and channel downcutting due to increased water velocities, resulting in deteriorated habitat conditions. Additionally, disconnection from the floodplain can lead to changes in the biotic structure of the aquatic ecosystem by limiting nutrient and organic material exchanges between the stream and floodplain.

One primary natural function of a floodplain is to store flood waters during high flow events. By impeding peak flood flows, natural floodplains tend to lower flood water elevations downstream and reduce downstream flood hazards and property destruction. In the Tillamook lowlands, considerable floodplain storage has been lost due to the construction of dikes and levees (TBNEP 1998), although such activities have not been common in the Miami River watershed. Many of these flood control structures, built to protect pasture lands from salt water inundation during tidal flooding, have also blocked the natural ability of the river floodplains to spread out flood waters, and thus the ability to slow and store flood waters flowing from the upland portions of the watersheds.

These attempts to control flooding have reduced the natural complexity of river channels and have separated the rivers from their floodplains. Such activities have occurred to a far greater extent in and along the larger rivers in the Tillamook Bay watershed than in and along the Miami River, However, the loss of natural floodplain function due to ditching and diking has impacted resources throughout the basin, including the fish and shellfish industries, which attracted commercial and residential development to the floodplain (Coulton et al. 1996). To some degree the diking has increased streambank erosion by increasing water depth and flow velocity between the dikes (Leopold et al. 1992). In addition, the removal of large woody debris has made streambanks more vulnerable to this type of erosion process.

The concept of working with the river's own natural functions to manage floods is replacing the concept of intervening in these processes to try to control floods (TBNEP 1998). Interest is growing in some areas in non-structural flood management methods, such as enforcing land use ordinances and restoring the floodplains.

3.5.2 Floodplain Development

Unaltered streams in natural lowland valley bottoms often meander through rich forested wetlands. These naturally meandering channels and adjacent wetlands typically have more frequent flooding, but lower flood peaks than human-altered streams and floodplains in similar geomorphic settings (Shields and Cooper 1994). Flood waves traveling through valley streams with natural riparian wetland floodplains have been observed to rise more gradually, reach lower peak elevations, and last longer than floods occurring on altered floodplains, which produced sharper, higher, and flashy flood conditions (Shields and Cooper 1994). Natural riparian wetlands help to distribute flood flows and store water for slower release.

Historic mapping of the Tillamook Valley floodplains (See Chapter 1) and anecdotal accounts of flooding prior to Euro-American settlement indicate that the historic floodplain landscape was much different than today. Historic valley landscapes were heavily forested bottom lands and wetlands which flooded often. These vegetative characteristics have been replaced by drained pastures and rural development. These changes have altered the ability of the floodplain to store and mitigate flood waters.

3.5.3 Gravel Removal

Sand and gravel are two of the most important natural resources extracted from the earth, based on tonnage (Cooke and Doornkamp 1978). The sand and gravel industry in Oregon has prospered since the 1940s. Throughout this time, Tillamook County rivers have provided a significant amount of this natural resource for local development interests. However, the in-channel extraction of sand and gravel has been scaled back in the county because of assumed direct and cumulative impacts on the fisheries and shellfish resource industries which share the same ecosystem.

A 1992 Tillamook County Gravel Mediated Agreement was developed in response to state agency recommendations to protect fish habitat and spawning areas. Under the agreement, commercial in-stream (within the banks of a river) gravel removal above the heads of tide of the Kilchis, Miami, Wilson, Trask, and Tillamook Rivers was phased out by October 1, 1997. Subsequently, a Coordinated Resource Management Plan regulates gravel removal from these rivers for non-commercial purposes, in an attempt to prevent unacceptable streambank erosion (Cleary 1996). ODSL and COE may consider applications for gravel extraction for flood control on Tillamook Bay rivers for tidal reaches of the rivers, including "no less than all areas west of Highway 101" (Cleary 1996). Such extraction proposals must also comply with Statewide Planning Goal 16 and be reviewed by DLCD.

Forecasts of aggregate use in Tillamook County show a mild increase in consumption to the year 2050 (TBNEP 1998). Total aggregate consumption for the County is estimated to be 28.9 million tons and virgin aggregate consumption will increase at a rate of 0.21% per year (Whelan 1995). Road construction will use up to 47% of the County's aggregate, and logging and forest roads will represent about 15% of the total consumption (Whelan 1995).

In 1996, Tillamook County took the necessary steps through the Goal 5 process to protect a number of upland aggregate sources. This action was prompted by an element of the Coordinated Resource Management Plan (CRMP) that phased out commercial gravel extraction from the Tillamook Bay rivers by October 1, 1997 (Cleary 1996). Six upland sources have been identified as capable of yielding enough aggregate to meet the County's future aggregate needs (Tom Ascher, Tillamook County, pers. comm. 1997).

Research into the effects of gravel removal on river morphology is still limited, but findings have indicated some river channels do have a certain amount of natural resiliency and may be capable of accommodating a degree of sediment removal. However, site-specific data should be obtained and physical responses should be carefully monitored.

These disruptions may result in downstream or upstream incision (down cutting) from the excavated area, as the river seeks dynamic equilibrium. In-stream gravel removal case studies reviewed by Collins and Dunne (1990) indicated that channel degradation can extend several miles upstream from the removal site, if the extracted gravel volume exceeds the natural supply. Therefore, it is important to establish river sediment removal rates compatible with the sustainable yield of the river. However, this is a very difficult estimation to make. Incision from gravel removal has been known to undermine river flood control works (Soil & Water 1985).

In-stream sand and gravel removal may also coarsen the bed sediments in streams, significantly impacting anadromous fish, because these fish require certain sizes of gravels for spawning (Allen 1969). Spawning fish have been observed to be capable of moving gravel up to a median size of approximately 10% of their body length (Kondolf and Wolman 1993). The removal of smaller gravels, of higher commercial value, may leave gravels too large for spawning fish to move. Other significant impacts to fisheries from in-stream dredging include the destruction of bottom-dwelling organisms and temporary water quality problems from turbidity.

3.6 Wetlands

Wetlands contribute critical functions to watershed health, including water quality improvement, filtration, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat. Because of the importance of these functions, wetlands are regulated by both state and federal agencies. Determining the location and extent of wetlands within a watershed is critical to understanding watershed structure and function.

3.6.1 National Wetlands Inventory

The primary source for wetland information used in this assessment was National Wetlands Inventory (NWI) maps created by the U.S. Fish and Wildlife Service. NWI maps were created from interpretation of 1:58,000-scale aerial photos that were taken in August of 1981. It is important to note that NWI wetland maps were based on aerial photo interpretation and not on ground-based inventories of wetlands. On-the-ground inventories of wetlands often identify extensive wetlands that are not on the NWI maps.

3.6.2 Wetland Extent and Types

Wetlands are an important landscape feature in the Miami River watershed, mainly in the lower watershed. Because digital NWI data were available for only part of the Miami River watershed, wetland extent for the entire watershed area was not calculated. In the limited areas for which data was available from NWI, the predominant wetland types identified were palustrine wetlands and a few tidal salt marshes (Figure 3.5). Palustrine wetlands are defined as all non-tidal wetlands dominated by trees, shrubs, and persistent emergents and all wetlands that occur in tidal areas with a salinity below 0.5 parts per thousand (Mitsch and Gosselink 1993, Cowardin et al. 1979). Some palustrine wetlands in the Miami river watershed have been disconnected from the stream by ditching and flood protection efforts. Estuarine wetlands are defined as deepwater tidal habitats and adjacent tidal wetlands that are usually semiclosed by land but have open, partially obstructed, or sporadic access to the ocean and in which ocean saltwater is at least occasionally mixed with freshwater (Mitsch and Gosselink 1993, Cowardin et al. 1979).

The Cowardin classification system is used by the NWI and others in classifying wetlands based on wetland type, vegetation or substrate type, and hydrology. The classification system is a hierarchical approach where the wetland is assigned to a system, subsystem, class, subclass, and water regime. Common types and characteristics of wetlands in the Miami River watershed are shown in Table 3.9.

3.6.3 Wetlands and Salmonids

Wetlands play an important role in the life cycles of salmonids (Lebovitz 1992, Shreffler et al. 1992, MacDonald et al. 1988, Healey 1982, Simenstad et al. 1982). Estuarine wetlands provide holding and feeding areas for juvenile salmonids migrating out to the ocean. These estuarine wetlands also provide an acclimation area for smolts while they are adapting to marine environments. Riparian wetlands can reduce sediment loads by slowing down flood water, allowing sediments to fall out of the water column and accumulate (Mitsch and Gosselink 1993). Wetlands also provide cover and a food source in the form of a diverse aquatic invertebrate community. Backwater riparian wetlands also provide cover during high flow events, preventing juvenile salmon from being washed downstream.

Wetlands that intersect streams represent important salmonid habitats (WPN 1999, Lebovitz 1992). ODFW habitat surveys identified a general lack of off-channel refuge habitat such as

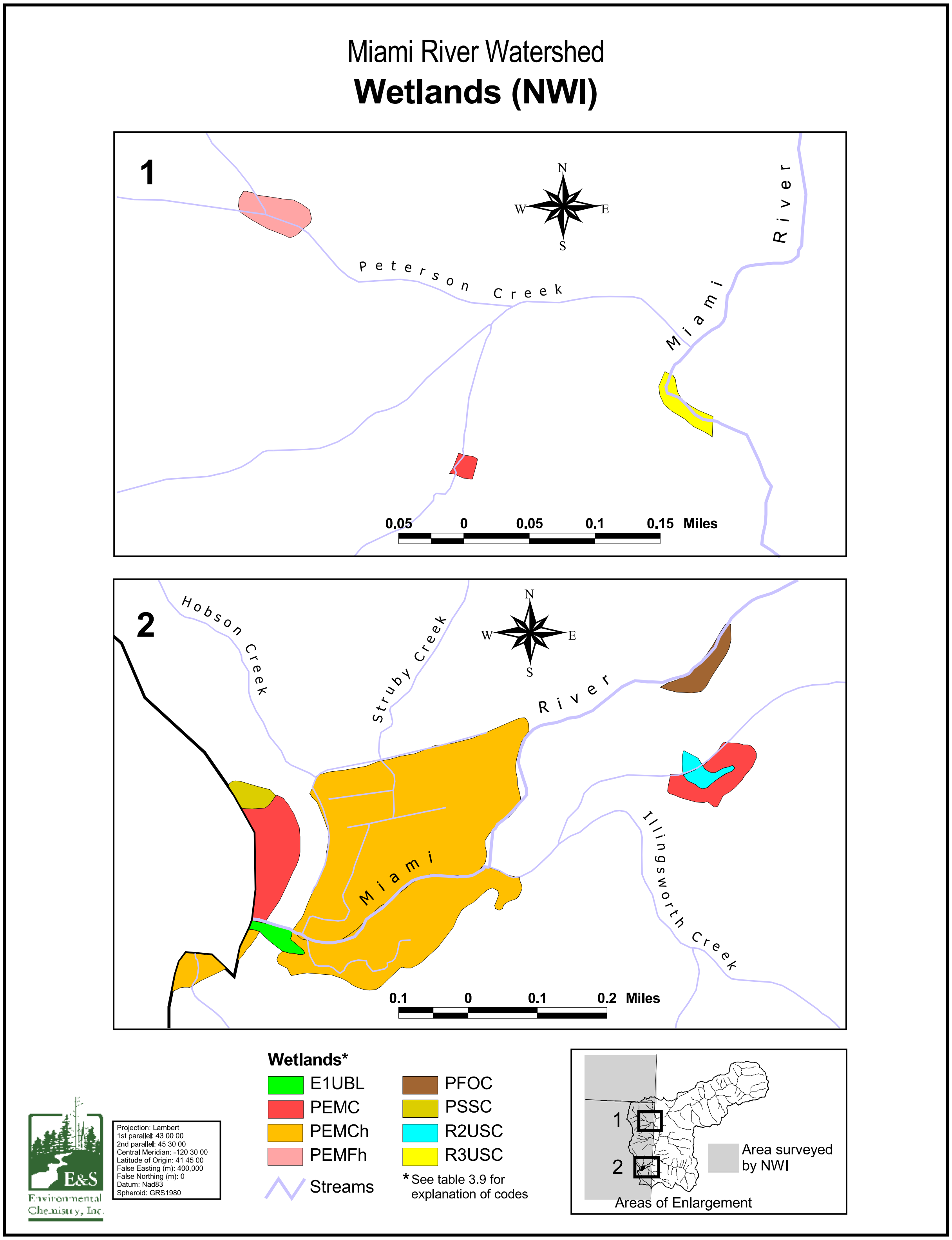


Figure 3.5. Location of wetlands in the Miami River watershed.

Table 3.9. Common NWI wetland types listed in the Miami River watershed. Wetland codes are from the Cowardin Wetland Classification used by NWI (Cowardin 1979).

Code	System	Class	Water Regime
E1UBL	E=estuarine	UB=Unconsolidated Bottom	L=Subtidal
PEMC	P= palustrine	EM=emergent	C = Seasonally flooded
PEMCh	P= palustrine	EM=emergent	C = Seasonally flooded h=Diked/impounded
PEMFh	P= palustrine	EM=emergent	F= Semipermanently flooded b= beaver
PFOC	P= palustrine	FO=Forested	C = Seasonally Flooded
PSSC	P= palustrine	SS=Scrub/Shrub	C = Seasonally Flooded
R2USC	R2=Riverine, Lower Perennial	US=Unconsolidated Shore	C = Seasonally Flooded
R3USC	R3=Riverine, Upper Perennial	US=Unconsolidated Shore	C = Seasonally Flooded

alcoves, side channels, and connected wetland areas. These areas are particularly important in the over-winter survival of coho salmon, sea-run cutthroat trout, chum salmon, and steelhead trout. Off-channel sites provide refuge from high sediment loads and high water velocities which occur in most larger stream channels during frequent winter rain events. Lack of off-channel refuge areas can be partially compensated for if in-channel refuge habitat (*e.g.*, root wads, debris jams, deep pools with complex cover) is abundant. However, as discussed previously, LWD is usually necessary for creation of such habitat in Coast Range streams.

According to the TBNEP environmental characterization report (TBNEP 1998), 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 success of some hatchery stocks. When many juveniles reach the estuary at once (such as during a heavy natural outmigration or following release from a hatchery), they may dramatically reduce the size of the local invertebrate populations. 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 is probably not a problem in Tillamook Bay now but should be considered for future salmonid management (TBNEP 1998).

Table 3.10 summarizes the habitat types and juvenile residency information for the five salmonid species found in the Miami River watershed. Of the five species, chinook salmon and chum salmon depend most on the estuary, followed by cutthroat trout. It is believed that most coho salmon and steelhead trout appear to use estuaries primarily as a migratory route and as a physiological transition zone for ocean residency. Additional research regarding fish utilization of estuaries is on-going.

Table 3.10. Primary estuarine habitats utilized by juvenile anadromous salmonids and approximate period of residency of individual fish (Healey 1982, Simenstad and Salo 1982, Iwamoto and Salo 1977).

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

3.6.4 Filling and Diking of Wetlands

Wetlands have been one of the landscape features most impacted by human disturbance. In the Pacific Northwest, it is estimated that 75% of the original wetlands have been lost to human disturbances (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1990). Somewhere between 50 and 90% of tidal marshes in individual Oregon estuaries have been lost, most as a result of agricultural activities (Frenkel and Morlan 1991, Boule and Bierly 1987).

Natural tidal marshes are sediment sinks. Dikes and levees constructed on tidal marsh lands have reduced the natural ability of estuary marshes to remove sediments by increasing the concentration of suspended riverine sediments transported directly into the bay. Sediments deposited in non-vegetated sloughs and mud flats are more likely to be resuspended by wind and wave action and transported into deeper navigable portions of the estuary than if they were deposited in vegetated tidal marshes. For estuaries experiencing a rising sea-level, restored tidal marshes can serve as long-term sediment sinks, keeping pace with the changing sea-level.

Some development has occurred in the Miami River floodplain, and it is likely to continue in association with increased population growth. Continued development has the potential to further impact wetlands within the watershed. Wetlands are regulated so that any filling of wetlands must be mitigated by either wetland construction or restoration. However, mitigation wetlands often cannot replace the lost functions of a filled wetland.

3.7 Conclusions

Aquatic and riparian habitats have been substantially altered throughout the Miami River watershed. Both habitat condition and access to habitat by biota, including anadromous fish, have been adversely impacted. Large woody debris (LWD) is generally lacking throughout the watershed. Although stream shading was rated as desirable in more than half of the subwatersheds, potential future recruitment of LWD is poor, largely because large conifers have been replaced by smaller-diameter deciduous trees in many riparian areas.

Fish passage barriers are numerous; 43% of surveyed culverts were judged to constitute impediments to fish passage. This seriously limits the utilization of otherwise-suitable fish habitat. Channelization, diking, ditching, and dredging of lowland areas have simplified habitat structure in the lowlands, altered access to aquatic biota, and changed sedimentation and flooding regimes. All of these changes have adversely impacted habitat quality. Both the tidal-influenced wetland and intertidal mudflat habitat types have been reduced since the mid-1800s. The filling and diking of wetlands have removed, or cut off access to, important off-channel refugia and overwintering areas for salmonid fish.

Thus, the overall condition of aquatic and riparian habitats in the watershed has been dramatically changed. Habitat quality for salmonid fish and other biota has been reduced. On-going and future efforts to restore habitat quality include, in particular, replacement of culverts that have blocked fish access to important habitat, improvement of LWD recruitment potential, and reconnection and restoration of wetlands. Specific locations for these activities should be determined in the Action Plan for this watershed.

CHAPTER 4. HYDROLOGY

4.1 Introduction

Human activities in the watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and the condition of aquatic habitats. Changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge. Some examples of human activities that can affect watershed hydrology are timber harvesting, urbanization, conversion of forested land to agriculture, and construction of road networks. The focus of the hydrologic analysis component of this assessment is to evaluate the potential impacts from land and water use on the hydrology of the watershed (WPN 1999). It is important to note, however, that this assessment only provides a screening for potential hydrologic impacts based on current land use activities in the watershed. Identifying those activities that are most affecting the hydrology of the watershed, and quantifying those impacts, would require a more in-depth analysis and is beyond the scope of this assessment.

4.2 Hydrologic Characterization

4.2.1 Watershed and Peak Flow Characterization

Peak Flow Processes

Peak flows occur as water moves from the landscape into surface waters. Peak flows occur in response to natural processes in the watershed and are characterized by the duration and volume of water during the rise and fall of a hydrograph. The primary peak flow generating process for the Coast Range and its associated ecoregions is rain events. The Coast Range generally develops very little snow pack. Snow pack that does develop in the coastal mountains is only on the highest peaks and is of short duration. Rain-on-snow events are infrequent in the Coast Range although these events have contributed to some of the major floods, including the floods of 1964 and 1996. These large floods are rare events, and we have no data to suggest that current land use practices have exacerbated the flooding effects from rain-on-snow events. Studies in the Coast Range found no appreciable increase in peak flows for the largest floods as a result of clearcutting (Rothacher 1971, 1973; Harr et al. 1975). Additionally, none of the Miami River subwatersheds have mean elevations above 2,000 ft in the rain-on-snow zone (Table 4.1). This hydrologic analysis therefore focuses on the effects of land use practices on the hydrology of these subwatersheds using rain events as the primary hydrologic process.

Snow pack is not monitored in the Miami River watershed. However, snow pack is monitored in the Wilson River watershed at Saddle Mountain and Seine Creek. The Saddle Mountain station is located at approximately 3,200 feet in elevation and has a mean snow water content of 6 inches (http://www.wrcc.wri.edu). The lower elevation site, Seine Creek, located at 2,000 feet, has a mean annual snow water content of 2.5 inches and is periodic in nature. In contrast, Oregon Cascade Mountain snow water accumulation is typically 20 to 25 inches at 4,000 feet and snow pack begins to accumulate in December and generally remains at least through March. Only 4% of the Miami River watershed is above 2,000 feet elevation and none of the watershed is above 3,000 feet, suggesting that snow contributions to flooding only occur in extreme snow accumulation years.

Topography

Topography in the Miami River watershed is characterized by steep headwaters that lead quickly into low gradient floodplains. Elevations in the watershed range from sea-level to 2,779 feet at its highest point. The Oregon Coast Range, including the Miami River watershed, is characterized by a strong orographic effect on precipitation as demonstrated by the large differences between lowland and upland precipitation totals (Table 4.1).

Flooding

Flooding is a natural process that contributes to both the quality and impairment of local environmental conditions. Consequently, flood management efforts attempt to reduce flood hazards and damage while protecting the beneficial effects of flooding on the natural resources of the system. Flooding causes, impacts, and management options are discussed in the Tillamook Bay environmental characterization report (TBNEP 1998).

River flooding tends to occur most commonly in December and January during periods of heavy rainfall or a combination of rainfall and snowmelt. River flooding combined with tidal flooding can extend the flood season from November to February. The lowland valleys are the most prone to flooding during these periods. Estimates of the floodplain acreage inundated during major floods and corresponding river watershed areas are provided in Table 4.2.

Table 4.1 Topographic features and precipitation amounts for the Miami River watershed based on GIS calculations. Annual precipitation was estimated from the PRISM model (Daly et al. 1994).

Subwatershed	Subwatershed Area (mi^2)	Mean Elevation (ft)	Minimum Elevation (ft)	Maximum Elevation (ft)	Mean Annual Precipitation (in)
Lower Miami River	3.9	627	0	1972	103
Middle Miami River	11.0	666	16	2451	111
Moss Creek	4.6	1024	13	2280	127
Upper Miami River	17.2	1142	89	2779	132
Total	36.7	931	0	2779	122

The Miami River watershed has a very small floodplain area (125 acres; Table 4.2). An important natural function of the floodplain is to reduce the severity of peak flows, thereby reducing down-stream impacts and flood hazards. The role of the Miami River floodplain is probably minimal in that regard. The floodplain has been largely disconnected from the river, however, reducing the natural ecological floodplain function. There is additional floodplain area along the bay shore adjacent to the mouth of the Miami River. This portion of the floodplaiin provides extensive wetland habitat. Impacts of floodplain loss are further discussed in Chapter 3, Aquatic and Riparian Habitats.

4.2.2 Stream Flow

The Miami River has been monitored for discharge by the State Water Resources Department for the past 25 years. The gage is located on the mainstem Miami above the

Table 4.2. Watershed and lowland floodplain areas of the rivers that flow into Tillamook Bay. (Source: TBNEP 1998)

River	Watershed Area (acres)	Floodplain Area (acres)
Kilchis	41,620	660
Miami	23,390	125
Wilson	123,557	4,900
Trask	113,864	3,600
Tillamook	36,395	1,720

confluence with Moss Creek. The Miami River demonstrates a typical coastal river discharge pattern with the majority of discharge occurring from November through April (Figure 4.1). Discharge during individual years sometimes deviates dramatically from the "average" patterns, however. Summer flows are low, averaging generally below 100 cfs. Flood events occur primarily in December through March.

4.3 Potential Land Use Impacts on Peak Flows

Increased peak flows can have deleterious effects on aquatic habitats by increasing streambank erosion and scouring (ODFW 1997). Furthermore, increased peak flows can cause downcutting of channels, resulting in a disconnection of the stream from the floodplain. Once a stream is disconnected from its floodplain, the downcutting can be further exacerbated by increased flow velocities as a result of channelization.

All subwatersheds of the Miami River watershed were screened for potential land use practices that may be influencing the hydrologic processes that contribute to increased peak flows and streambank erosion (WPN 1999). This screening effort only deals with the most significant processes affected by land use (i.e runoff). There are four land use types that can significantly affect the hydrology of a watershed: forestry, agriculture and rangeland, forest and rural roads, and urban or rural residential development.

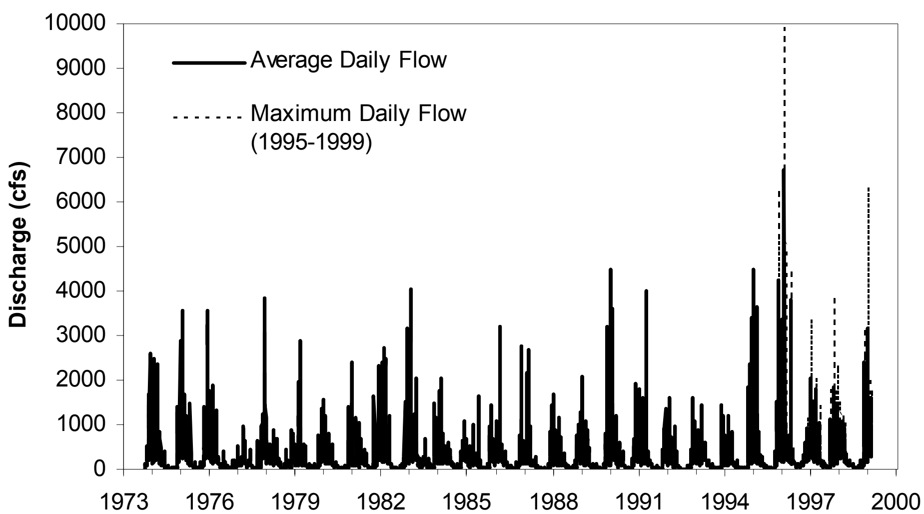


Figure 4.1. Miami River discharge for the availabe period of record (Data from Oregon Water Resources Dept.).

4.3.1 Forestry

Forestry practices have the potential to influence the magnitude of flooding, but it is difficult to quantify such effects because of the large natural variability in discharge. This difficulty has contributed to over a century of debate in the United States concerning the role of forest conservation in flood protection (Naiman and Bilby 1998). Studies in the Oregon Coast range found no appreciable increase in peak flows for the largest floods that could be attributed to clearcutting (Rothacher 1971, 1973; Harr et al. 1975). Specific information is not available regarding changes to the hydrology of the Miami River that might be attributable to forestry.

Although the largest floods are most important from a flood hazard standpoint, the effects of increases in smaller magnitude peak flows cannot be discounted from a stream channel or ecological standpoint (Naiman and Bilby 1998). High flows constitute a natural part of the stream flow regime and are largely responsible for transporting sediments and forming channels. Consequently, increases in the magnitude of moderate peak flows can lead to channel incision thorough bank building and erosion. Because forest harvest practices are common in the watershed, there may be effects of forestry on watershed hydrology. These might include reduced evapotranspiration, increased infiltration and subsurface flow, and increased overland flow (Naiman and Bilby 1998). Such changes may result in modified peak and low flow regimes and subsequent effects on in-stream aquatic habitat quality. They are difficult to quantify, however, and have not been determined specifically for the Miami River watershed.

4.3.2 Agriculture and Rangeland

The impacts of agriculture on river hydrology are dependent upon specific land use and management practices as well as the physical characteristics of the soil being farmed. Those management practices that change the infiltration rate of the soils are the most influential in changing the hydrologic regime (WPN 1999). Agriculture has the greatest impact in those areas where soils have naturally high infiltration rates.

The Natural Resources Conservation Service (NRCS) has mapped soils across the state of Oregon. As a part of this mapping process, soils were grouped into four hydrologic classes based on minimum infiltration rates. As a part of the NRCS method runoff curve numbers are assigned to areas based on soil type, land cover, and farming practice. These runoff curve numbers can be utilized to estimate runoff in small agricultural and rural watersheds. The estimated runoff can then be compared to estimated background conditions to identify likely changes in runoff as result of land management practices. Digital soils data for the Miami River watershed were not yet available at the time of preparation of this assessment, however, and this kind of generalized analysis was not conducted.

Only a very small percentage of the Miami river watershed is in agricultural land use (Figure 1.4). Consequently, there is little potential for agricultural practices to change the infiltration rates of the soil sufficiently as to influence the overall watershed hydrology.

Other factors associated with agricultural land use that may have slightly impacted the hydrology of the Miami River watershed include draining and ditching of wetlands and disconnection of the floodplain. Agricultural land use is concentrated in the lower elevations of the watershed, generally in the floodplains of the Miami River. Historically, these floodplains were wetland areas that trapped sediments and accumulated plant material, resulting in rich fertile soils. Recognizing the economic value of these soils, the floodplains were drained and ditched for agricultural purposes, mostly as pasture. Disconnecting the floodplain from the river has resulted in the loss of flood attenuation capacity, increased peak flows, down-cutting of channels, and increased flow velocities. Further discussion of problems associated with disconnection of the floodplain and wetland loss can be found in Chapter 3 (Aquatic and Riparian Habitats).

4.3.3 Forest and Rural Roads

Road construction associated with timber harvest and rural development has been shown to increase wintertime peak flows of small to moderate floods in Oregon Coast Range watersheds (Harr 1983). This assessment uses a roaded area threshold of 8% to screen for potential impacts of roads on peak flows (discharge increase >20%; WPN 1999). Watersheds with a greater than 8% roaded area are considered to have a high potential for adverse hydrologic impact, 4 to 8% have a moderate potential, and less than 4% have a low potential.

According to GIS calculations from the ODF fire roads coverage for the portions of the watershed in forested land use, all of the subwatersheds in the Miami River watershed were considered to have a low potential impact from the density of forest roads (Table 4.3). However, this GIS coverage may significantly under-estimate actual on-the-ground road conditions in the watershed. The GIS coverage was compared to a 1:24,000 road coverage for the area and it was

Table 4.3 Forest road summary for the Miami River watershed based on GIS calculations. The roads coverage data used for this analysis were obtained from the BLM (fire roads).

Subwatershed	Subwatershed Area (mi^2)	Area Forested (mi^2)	Forest Roads (mi)	Roaded Area (mi^2)*	Percent Forested Area in Roads	Relative Potential Impact
Lower Miami River	3.8	3.2	19.4	0.1	2.8	Low
Middle Miami River	11.0	10.5	57.9	0.3	2.6	Low
Moss Creek	4.6	4.5	19.4	0.1	2.0	Low
Upper Miami River	17.2	17.2	44.0	0.2	1.2	Low
Total	36.6	35.4	140.7	0.7	1.9	Low

* Width used to calculate roaded area was 25 ft.

determined that the results were fairly similar. In a study conducted in the Oregon Mid-Coast watersheds (Earth Design Consultants, Inc. 2000), 1:24,000 road coverages under-represented actual road densities by 1.7 times.

4.3.4 Urban and Rural Residential Areas

According to GIS calculations from the ODF fire roads coverage, all of the subwatersheds in the Miami River watershed except the Upper Miami River were considered to have a low potential for adverse hydrologic impact from the density of rural roads (Table 4.4). Only the Upper Miami River had a significant portion (6.3%) in roaded area, but that still represents only a moderate potential for hydrologic impacts.

4.3.5 Other Potential Hydrologic Impacts

Past fires changed the ability of the surface soils to store runoff from forested areas (c.f., Coulton et al. 1996). Burned areas, and especially areas of repetitive burns, typically show a reduced ability to store moisture in surface soils (TBNEP 1998). The Tillamook Burns of 1933, 1939, 1945, and 1956, and especially the repeated burns and construction of salvage logging roads, undoubtedly disrupted the infiltration and water storage capacity of the upland areas. The loss of this natural flood attenuation mechanism, combined with the steep slopes and impermeable soils, increased the frequency and quantity of runoff and sediment delivery from heavy rainfall events. Landslides from natural slope failures or induced by road and culvert construction added pulses of sediment to the river channels and changed the ability of the rivers

Table 4.4 Rural residential road summary for the Miami River watershed based on GIS calculations. The roads coverage data used for this analysis were obtained from the BLM (fire roads).

Subwatershed	Subwatershed Area (mi^2)	Rural Area (mi^2)	Rural Road Length (mi)	Rural Roaded Area from Buffers (mi^2)	Percent Rural Area in Roads (%)	Relative Potential Impact
Lower Miami River	3.8	0.3	2.3	0.011	3.6	Low
Middle Miami River	11.0	0.4	1.2	0.006	1.4	Low
Moss Creek	4.6	0.1	0.6	0.003	3.7	Low
Upper Miami River	17.2	0.01	0.2	0.001	6.3	Moderate
Total	36.6	0.8	4.2	0.020	2.5	Low

to convey flood water (Coulton et al. 1996). We have no quantitative data, however, regarding the importance of these processes to the hydrology of the watershed.

4.4 Conclusions

Screening for land management activities that may be affecting natural hydrologic conditions suggests that roads have little effect on current hydrologic regimes, but other hydrologic impacts may have occurred in response to the Tillamook Burns and/or agricultural practices (especially draining of wetlands) in the valley bottoms. Loss of historical flood plain acreage and land cover (such as wetlands, forested valley bottoms) have likely had significant impacts on hydrologic conditions in the Miami River watershed.

CHAPTER 5. WATER USE

Under Oregon law, all water is publicly owned. Consequently, withdrawal of water from surface and some groundwater sources requires a permit, with a few exceptions. The Oregon Water Resources Department administers state water law through a permitting process that issues water rights to many private and public users (Bastasch 1998). In Oregon, water rights are issued as a 'first in time; first in right' permit, which means that older water rights have priority over newer rights. Water rights and water use were examined for each of the water availability watersheds (watersheds defined by the Oregon Water Resources Department for the assessment of flow modification).

Water that is withdrawn from the stream has the potential to affect in-stream habitats by dewatering that stream. Dewatering a stream refers to the permanent removal of water from the stream channel, thus lowering the natural in-stream flows. For example, a percentage of the water that is removed from the channel for irrigation is permanently lost from that watershed as a result of plant transpiration and evaporation. In-stream habitats can be altered as a result of this dewatering. Possible effects of stream dewatering include increased stream temperatures and the creation of fish passage barriers.

Water is appropriated at a rate of withdrawal that is usually measured in cubic feet per second (cfs). For example, a water right for 2 cfs of irrigation allows a farmer to withdraw water from the stream at a rate of 2 cfs. Typically, there are further restrictions put on these water rights, including a maximum withdrawal amount allowed and the months that the water right can be exercised. Identifying all of these limits is a time-consuming and difficult task, which is beyond the scope of this assessment. However, for subwatersheds identified as high priority basins, this should be the next step if water use is judged to pose a potential problem.

The city of Garibaldi, with a population of about 900, is situated on the north shore of Tillamook Bay, adjacent to the mouth of the Miami River. The economy is centered on forestry, fisheries, and tourism, each of which exhibits intensive seasonal water use. Within the fish processing industry alone, water use during peak operation equals the highest water use of many small cities (Garibaldi Master Water Plan 1993). The summertime population of Garibaldi swells dramatically to accommodate coastal tourists. This places significant demands on the water system.

5.1 In-stream Water Rights

In-stream water rights were established by the Oregon Water Resources Department for the protection of fisheries, aquatic life, and pollution abatement; however, many remain junior to most other water rights in these watersheds. The Middle and Lower Miami River subwatersheds currently have in-stream water rights established for the protection of aquatic life (Table 5.1; Appendix B). In addition, ODFW established in-stream water rights for the protection of anadromous and resident fish (Table 5.1). However, these water rights are junior to almost all of the other water rights in the watershed. Developing in-stream water rights that are more senior than current in-stream water rights would aid in the protection of in-stream flows in the Miami River watershed. This could be accomplished through water right trading and leasing through the Oregon Water Resources Department.

Table 5.1. In-stream water rights in the Miami River watershed. Data were obtained from the Oregon Water Resources Department.

Water Availability Watershed	Priority	Purpose
Miami River @ 14301300	1991 1973	Anadromous and resident fish rearing Supporting Aquatic Life
Miami River @ mouth	1991 1973	Anadromous and resident fish rearing Supporting Aquatic Life
Moss Creek @ mouth	1991	Anadromous and resident fish rearing
Prouty Creek @ mouth	1991	Anadromous and resident fish rearing
Peterson Creek	1991	Anadromous and resident fish rearing

5.2 Consumptive Water Use

5.2.1 Irrigation

A small amount of water is appropriated for irrigation in the Middle and Lower Miami subwatersheds (Figure 5.1, Table 5.2). A very small amount is also appropriated in the Prouty Creek (0.05 cfs) subwatershed.

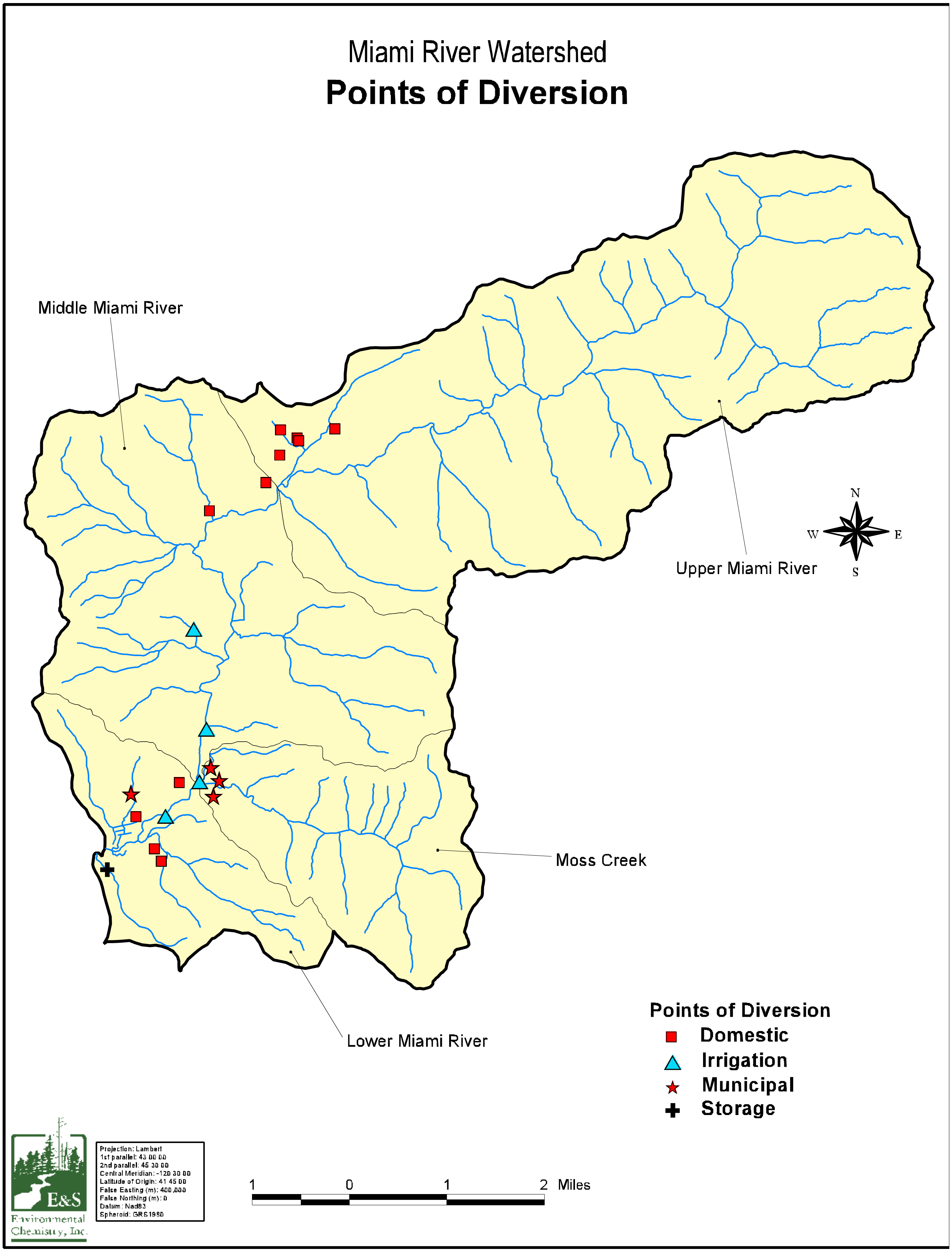


Figure 5.1. Water withdrawals in the Miami River watershed. Data were obtained from the Oregon Water Resources Department.

Table 5.2. Water use and storage in the Miami River watershed (in cfs). Data were obtained from the Oregon Water Resources Department

Water Availability Basin	Irrigation	Municipal	Domestic	Fish/ Wildlife	Other	Total
Miami River @ 14301300	1.1	0.74	0.1	–	–	1.94
Miami River @ mouth	0.4	0.83	0.04	–	–	1.27
Moss Creek @ mouth	–	1.12	–	–	–	1.12
Prouty Creek @ mouth	0.05	–	0.03	–	–	0.08
Total	1.55	2.69	0.17	0	0	4.41

5.2.2 Municipal and Domestic Water Supply

Most water appropriations in the Miami River watershed are for municipal use (Table 5.2, Figure 5.1,). Most of this water is appropriated in the lower elevations of the Miami River watershed in both the Lower and Middle Miami River subwatersheds as well as the Moss Creek subwatershed. The Lower and Middle Miami and Prouty Creek subwatersheds also provide small amounts of domestic water use usually associated with rural residential areas.

5.3 Water Availability

5.3.1 Water Availability Models

The Oregon Water Resources Department has developed models to assess the potential impacts of water withdrawals on stream flows (Robison 1991). These model outputs are available to the public on the OWRD website (http://www.wrd.state.or.us). They use predicted water loss based on the type of use for the appropriated water. Losses are then compared to predicted in-stream flows, based on a user- assigned exceedence level. We have chosen a 50% exceedence, which represents stream flows that would be expected at least 50% of the time.

Based on current water availability model outputs for the 50% exceedence level, there is little concern for dewatering in the Miami River watershed on average. None of the subwatersheds demonstrated water loss greater than 2% of the predicted in-stream flows (Table 5.3). Consequently, it is unlikely that water withdrawals from the Miami River and its tributaries are having a large impact on current average in-stream flows throughout most of the year. However, any time water is appropriated for out-of-stream use, there is a potential for some effects on the in-stream habitats to occur during periods of very low flow. It is possible

Table 5.3. Dewatering potential in the Miami River watershed, based on a 50 percent exceedence*.

	Dewatering Potential (%)**					Overall Dewatering Potential	
Water Availability Watershed	Jun	Jul	Aug	Sep	Oct	Average Percent Withdrawal	Potential
Miami River @ 14301300	0.2	0.7	0.7	0.2	0	0.4	Low
Miami River @ mouth	1.1	2.6	2.0	0.5	0.1	1.3	Low
Moss Creek @ mouth	0	0	0	0	0	0.0	Low
Peterson Creek @mouth	0	0	0	0	0	0.0	Low
Prouty Creek @ mouth	0.4	1.6	2.9	1.6	0.6	1.4	Low
Total	1.7	4.9	5.6	2.3	0.7	3.0	Low

* A 50% exceedence represents the amount of water than can be expected to be in the channel 50% of the time or one out of every two years.

** The dewatering potential is the percent of in-stream flows that are appropriated for consumptive use during the low flow months.

that water withdrawals during low flow periods may contribute to water quality and aquatic habitat degradation during critical low-flow time periods.

5.3.2. Low Flow History of the Miami River

Although the model outputs suggested that in-stream flows would generally not be affected by appropriated water uses in the Miami River watershed, there is some potential for low flow situations to deleteriously affect in-stream aquatic habitats. Using USGS stream flow data at the Miami River gage for the period of 1973 to 1999, we established a frequency for the mean daily flows that were less than the established in-stream water right. We used the in-stream water right as an indicator of in-stream flow conditions for salmonids, assuming that flows below the in-stream water right constituted poor conditions for salmonids and other aquatic biota.

Mean daily discharge during the low flow months (July through October) was less than 5% below the in-stream water right for July, August and September. However, mean daily discharge in October was below the in-stream water right 61% of the time (Table 5.4; Figure 5.2). The low flow history for the period 1973 to 1998 showed that lowest mean daily flow values each year often occurred in August, September, or October. The lowest mean daily flow values have frequently been less than 10 cfs since 1987 (Figure 5.2).

Table 5.4. Number of days that the mean daily flow was below the in-stream water right established for protection of anadromous fish. These data are for the Miami River gage location for the period of 1973 to 1991.

Month	In-stream Water Right*	Number of Days Having Data	Days Below In-stream Water Right	
			Number	Percent
1	80	806	28	3.5
2	80	722	21	2.9
3	80	775	36	4.6
4	80	750	40	5.3
5	40	775	8	1.0
6	20	734	13	1.8
7	8	745	5	0.7
8	8	744	29	3.9
9	8	721	18	2.5
10	40/80**	797	448	56.2
11	100	780	123	15.8
12	100	806	45	5.6
Grand Total		9155	814	8.9

* For protection of anadromous fish (in units of cfs)
** The water right changes from 40 to 80 cfs on October 16th

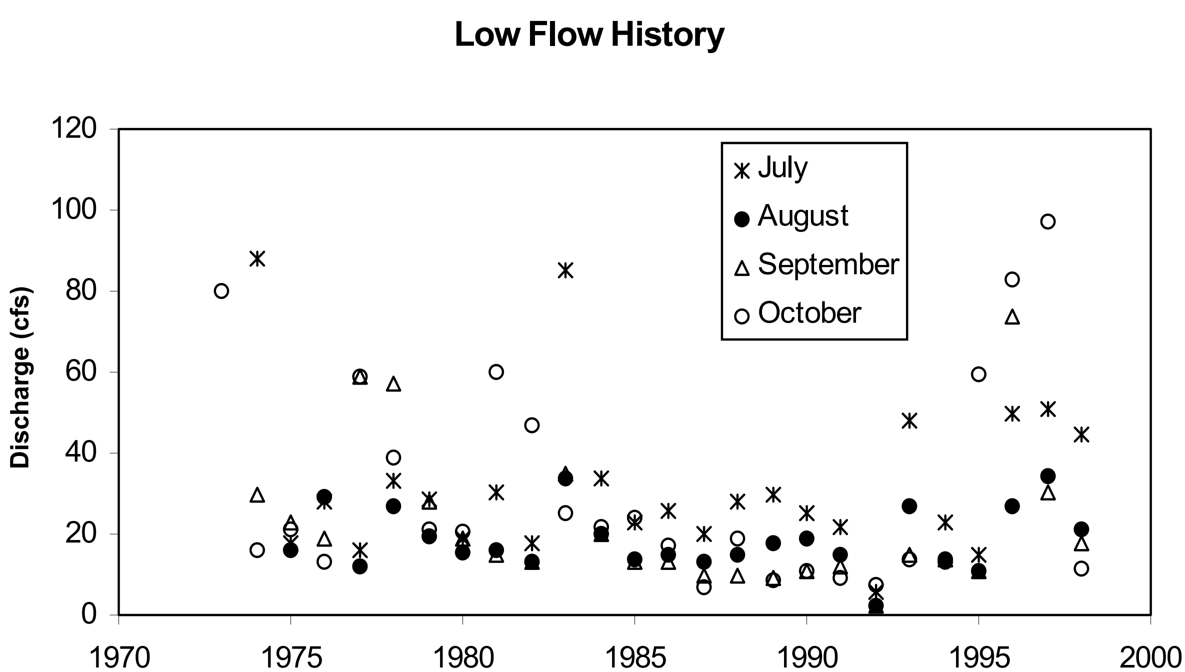


Figure 5.2. Minimum value for each month (July through October) in each year of the mean daily flow within that month.

Table 5.4 gives the number and percentage of days during the period 1973 to 1991 during which the mean daily flow at the Miami River discharge station (above Moss Creek) was below the respective in-stream water right for protection of anadromous fish. During the driest months, July through September, the in-stream water right is low (8 cfs), and the mean daily flow was consistently below that value only 4%, or less, of the time. However, during October and November, the in-stream water right is much higher (40 to 100 cfs; Table 5.4) and the mean daily flow was often below the water right. This may be more a function of the water right being set too high for these months than the result of excessive water withdrawal.

If the in-stream water right reflects habitat conditions for salmonids, there is a potential for low flow conditions to have a deleterious effect on local salmonid populations. Consequently, any out-of-stream water use during low flow situations will only exacerbate habitat problems. It is our recommendation that in-stream water rights continue to be protected and in-stream flows monitored during very low flow conditions.

5.3.3 Flow Restoration Priorities under the Oregon Plan for Salmon

ODFW and OWRD prioritized coastal watersheds for recovery of anadromous salmonids based on in-stream flow conditions. Priorities were developed by season (spring , summer, fall, winter) and given a rating of low, moderate, high, or highest. The Miami River watershed and all of its associated subwatersheds were given a high rating for summer flow restoration priority (Appendix B). The Miami River is a State priority for streamflow restoration. The Oregon Plan website (www.oregon-plan.org/AnnRept/2-implement/ agency.reps/imp-odfw.pdf) describes some of the parameters that were used to rank subwatersheds for flow restoration. Some of these parameters include fish resources and habitat, risk factors, streamflow restoration optimism, water use, and endangered or threatened species.

5.4 Conclusions

Appropriated water in the Miami River watershed represents only a small fraction of modeled in-stream flows. Consequently, it is expected that surface water withdrawals generally have little effect on current in-stream habitats. However, the Miami River watershed is a State priority for stream flow restoration suggesting that the Miami River is experiencing low flow issues. Consequently, any surface water withdrawals during very dry months can exacerbate existing streamflow deficiencies. In-stream flow requirements for salmonids needs to be further evaluated to determine actual impacts of surface water withdrawals on salmonid populations. It is our recommendation that in-stream water rights continue to be protected and in-stream flows monitored during very low flow conditions.

CHAPTER 6. SEDIMENT SOURCES

6.1 Introduction

Erosion is a natural watershed process in the Oregon Coast Range. The bedrock geology of much of the Oregon Coast is composed of weak, highly erosive rock types. However, most experts agree that land use practices have increased the rate of erosion in many coastal watersheds (WPN 1999, Naiman and Bilby 1998). High levels of sediment in rivers and streams are associated with loss of agricultural lands and the filling of bays and estuaries. Sediment is also negatively impacting many aquatic organisms, including several species of salmon that are federally listed as threatened or endangered under the Endangered Species Act. Understanding the role of erosion and its interaction with other watershed processes is critical to maintaining a healthy ecosystem. Issues regarding erosion in the Tillamook Bay Watershed have been the source of concern for several decades. Past studies were recently analyzed and summarized by the National Estuary Project (NEP).

Most Pacific Northwest estuaries, including Tillamook Bay, are depositional environments: they accumulate sediment (Komar 1997). Sediment in Tillamook Bay comes from marine sources, the five major rivers and numerous smaller streams which flow into Tillamook Bay, and from bayshore erosion (Glenn 1978). In recent decades the upper (southern) end of the Bay (bayhead delta) has become very shallow, leading to speculation that the uplands have been producing more sediment than the Bay can accommodate while retaining its historic dimensions (TBNEP 1998).

Upland processes that deliver sediment to the stream system include landslides and surface erosion. In lowland streams and rivers, erosion occurs principally as streambank erosion, which often causes significant losses of riparian agricultural land. Wildfires alter soil conditions, setting the stage for increased rates of erosion. The majority of sediment deposition into the stream system occurs during large storm events. The major floods of February, 1996 and minor floods of 1998 and 1999 focused attention on the sediment accumulating in Tillamook Bay, which is perceived to be blocking rivers and channels.

There were several assumptions made about the nature of sediment in this watershed (WPN 1999). First, sediment is a normal and critical component of stream habitat for fish and other aquatic organisms. Second, the more that sediment levels deviate (either up or down) from the natural pattern in a watershed, the more likely it is that aquatic habitat conditions will be significantly altered. Third, human-caused increases in sediment occur at a limited number of locations within the watershed that can be identified by a combination of site characteristics and land use practices. Finally, sediment movement is often episodic, with most erosion and downstream sediment movement occurring during infrequent and intense runoff events.

Knowledge of current sources of sediment can provide a better understanding of the locations and conditions under which sediment is likely to be contributed in the future. These sources can then be evaluated and prioritized, in the process of developing an Action Plan, based on their potential effects on fish habitat and water quality to help maintain natural ecosystem functioning.

6.2 Screening for Potential Sediment Sources

OWEB has identified eight potential sediment sources that have a significant impact on watershed conditions (WPN 1999). Not all are present in every watershed, and they vary in influence depending on where and how often they occur. The potential sediment sources include slope instability, road instability, rural road runoff, urban area runoff, crop lands, range or pasture lands, burned areas, and other identified sources.

In this watershed, slope instability, road instability, and rural road runoff are the most significant sediment sources. Shallow landslides and deep-seated slumps are common in the Oregon Coast Range. Streamside landslides and slumps are major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Rural roads are a common feature of this watershed, and many are present on steep slopes. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of rural roads, especially unpaved gravel and dirt roads, indicates a high potential for sediment contribution to the stream network.

Agricultural and pasture land runoff, as well as the history of fire in the Tillamook region are also contributing factors. However, agricultural and pastoral lands occupy a small portion of the watershed. Agricultural lands account for approximately 1.5 percent of this watershed, and are mostly located at the lower elevations. There is no urban runoff in this watershed.

6.3 Slope Instability

Landslides are the main source of sediment in the Miami River watershed. A landslide is defined as "the movement of a mass of rock, debris, or earth down a slope" (National Research Council 1996). Often landslides gather large amounts of organic material, such as downed logs and woody debris, as they travel downslope. They are extremely variable in size and velocity, usually falling into two categories: "shallow-rapid" and "deep-seated". Shallow-rapid landslides are typical on steep forested hillslopes (Mills 1997). Shallow rapid landslides include rock slides, debris slides and debris flows. A small debris slide (generally occurring on steep slopes with shallow soils) becomes a debris flow if the sliding soil, moving downslope, scours and entrains additional soil and vegetation in its path. In areas with steep slopes, debris flows are the dominant erosional mechanism (Mills 1997). Deep-seated landslides are more commonly slow-moving and are also highly variable in size, although a very large, rapidly moving deep-seated landslide occurred along the Wilson River in 1991 (Mills 1997).

Under natural conditions, geology, topography, and climate interact to initiate landslides. With human intervention, natural conditions may be modified in ways that increase the likelihood of landslide initiation. Road-building often creates cuts and fills. In a slide-prone landscape, road-cuts may undercut slopes and concentrate runoff along roads, and road-fills on steep slopes may give way, initiating a landslide (NRC 1996). Vegetation removal, such as by logging or wildfire, may also increase the likelihood of landslide occurrence.

Landslides and debris flows can have both positive and negative effects on fish in streams. A landslide from a forested hillside will contain soil, organic material, and a substantial amount of large woody debris. This mixture causes significant changes in the affected stream reach (Chesney 1982). In the short term, a debris flow can scour a channel or remove beneficial prey (benthic macroinvertebrates) and channel structures. Over the long-term, these events deliver woody debris, organic matter, and gravel that could result in the reestablishment of productive aquatic habitat and provide an important reset mechanism to the stream ecosystem.

There are few estimates of sediment yield from forest lands in the Tillamook region. To date, no comprehensive aerial photo or on-the-ground inventories of landslides have been conducted in the Miami River watershed. A 1978 study by the U.S. Department of Agriculture, prepared for the Tillamook Bay Task Force, estimated sediment yield for the entire Tillamook watershed. Upland erosion rates in Tillamook Bay's Watershed have increased due to human activities, but the exact amount of increase is unclear. The USDA (1978) report used the Universal Soil Loss Equation (USLE) to estimate sediment production for forested lands. Since this technique tends to overstate sheet and rill erosion on forest land — particularly where the soil has high infiltration rates, as are typical of the volcanic soil areas in the Pacific Northwest — the upland erosion study results are not presented here.

One study in 1978 used false color infrared photographs to identify human-induced and natural landslides in the Tillamook area (Benoit 1978). Of the 4,680 landslides identified, 4,440 (95%) were classified as human-induced. Landslides were considered "human induced" if they occurred near roads, fire lines, or timber harvest or salvage activities. The liberal criteria for human impacts may tend to overstate the anthropogenic role, however. Other studies which used only aerial photos have reported more landslides in managed areas than in unmanaged areas, but not on the scale of Benoit's (1978) findings. An increase of 580% (6.8 fold) is typical (Amaranthus et al. 1985). Aerial photo studies like Amaranthus et al.'s (1985) and Benoit's (1978) have been shown to be biased, however, due to the inability to identify landslides under forest canopy (Pyles and Froehlich 1987, Mills 1997); aerial photo surveys therefore under-estimate the number of landslides under forest canopy.

In 1999, the Oregon Department of Forestry compiled and mapped landslide information from state and federal agencies for all of western Oregon. However, only one landslide event was recorded in the Miami River watershed. This was probably largely because no surveys of landslides have been conducted for the Miami River watershed. Landslide frequencies in more thoroughly-studied neighboring watersheds suggest that the actual number of landslides in the Miami River watershed may actually be fairly high. The density of landslides in a topographically and geologically similar area of the Wilson River watershed was 11.1 slides per square mile. For a more detailed discussion of landslides and erosional processes in the Wilson River watershed, see the Wilson River Watershed Assessment (Sullivan et al. 2001).

ODF created debris flow hazard maps in 1996 to characterize the future potential for landslide activity, based on watershed features such as slope, channel confinement, and geology. According to potential debris flow hazard maps created by ODF, approximately 84% of the Miami River watershed is in the debris flow activity zones (Figure 6.1). Thirty-eight percent of the watershed was classified as high risk, and 46% as moderate risk (Table 6.1). The Upper Miami River subwatershed had 96% of its area in the debris flow risk zone, and most of that was in the high risk category. The subwatershed with the greatest percentage of high risk coverage was the Upper Miami River (68%), followed by the Moss Creek subwatershed (48%).

Comparatively, a slightly greater percentage of the Wilson River watershed was in the debris flow risk zone. Overall, more than three-quarters of the Wilson River watershed was in the debris flow activity zones. The percentages of moderate and high risk zones were 40% and 38%, respectively.

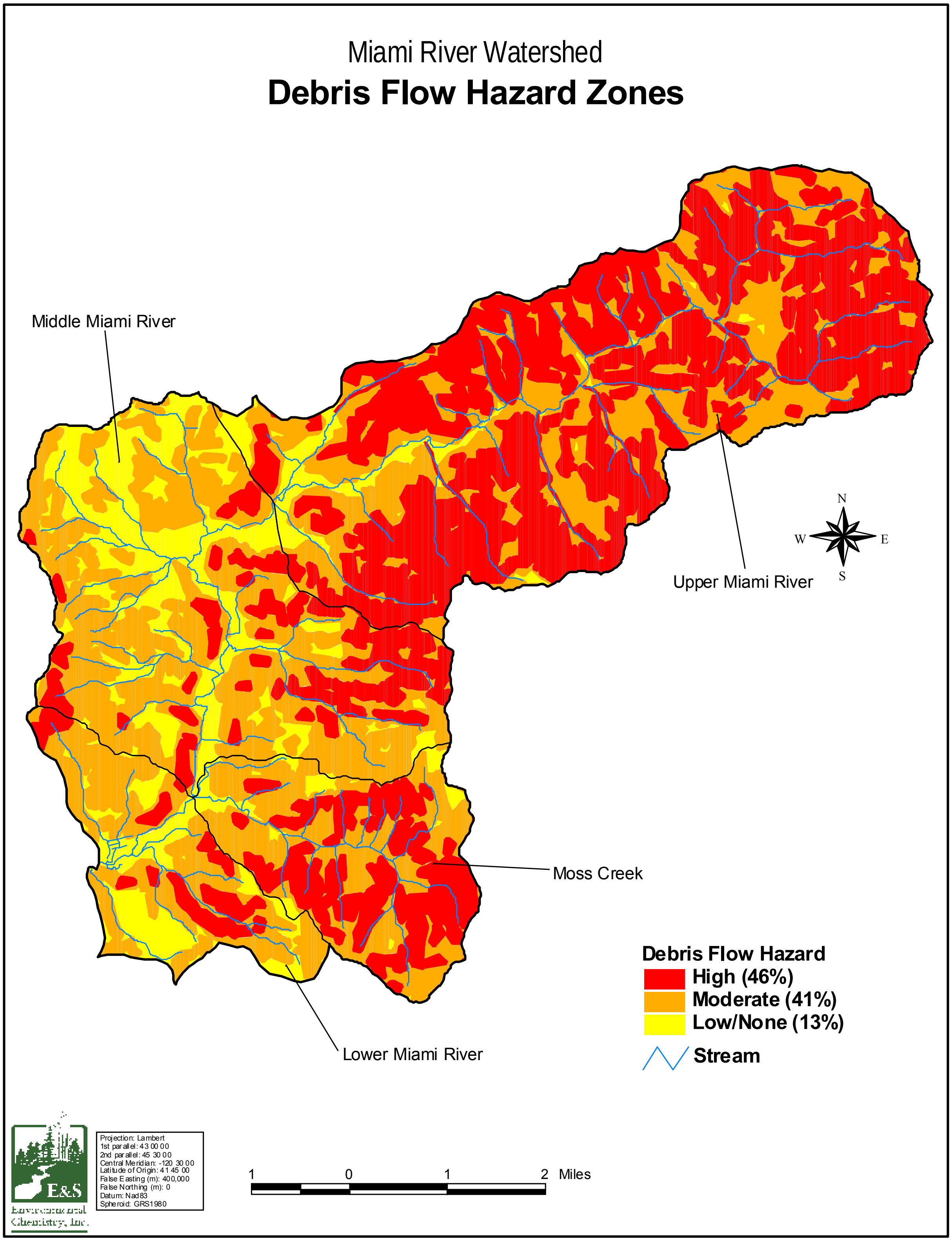


Figure 6.1. Debris flow hazard zones for the Miami River watershed.

Table 6.1. Potential debris flow hazard zones in the Miami River watershed.				
	Watershed Area (sq. mi.)	High (%)	Moderate (%)	High+Mod (%)
Lower Miami River	3.9	17	56	74
Middle Miami River	11.0	19	54	73
Moss Creek	4.6	48	46	94
Upper Miami River	17.2	68	28	96
Watershed Average		38	46	84?

6.4 Road Instability

Roads constitute the primary source of increased sediment from forestry-related activities in the western United States (Mills 1997). Landslide frequency can be greatly accelerated by road building and management practices (Sidle et al. 1985). Road construction, especially on steep slopes, can lead to slope failure and result in increased landslide activity (WPN 1999, Sessions et al. 1987). Road stability is partially determined by the method of construction. For example, sidecast roads are built by using soil from the inside portion of a road to build up the outside, less stable portion of the road. Sidecast roads work well in moderately steep terrain, but in steep terrain the sidecast material frequently slides off the roadbed, initiating landslides or debris flows. Road crossings with poorly designed culverts can fail and wash out, create gullies, and deliver large pulses of sediment to the channel. Sediment delivery to streams depends on the percentage of the road drainage system which discharges directly to the channel; the proximity of non-stream discharges (*i.e.*, discharges across the hillside) to a channel; the volume of water involved and the potential for gully development (stream extension); and the volume of eroded material available (Mills 1997).

Unfortunately, no data were available regarding road-related landslides in the Miami River watershed at the time of the writing of this document. ODF, which owns approximately 60% of the watershed, recently completed the fieldwork for a comprehensive road condition inventory, but the GIS data were not complete at the time of this report, so spatial analysis was not possible. However, we were able to conduct preliminary analyses at the scale of the Tillamook Bay watershed. In ODF lands throughout the Tillamook Bay watershed, there are approximately 1143 miles of road (Harrison, pers comm.). ODF surveyed over a thousand sidecast road sites. Of these, over half were determined by ODF to pose a moderate or high risk of contributing sediment to a stream if a road-related landslide was to occur. The overall density of these high-risk sites was approximately 1 site per every 2 miles of road. However, since these data were not specific to the Miami River Watershed, they only provide a region-wide sense of the potential for sediment contribution from roads on ODF lands.

We also conducted a GIS-based analysis of road-stream crossings. We found an average density of 2.7 crossings per square mile in the Miami River watershed. The highest density was in Moss Creek and Lower Miami River, with 4.6 crossings each per square mile. The lowest density was 1.7 crossings/sq. mi. in the Upper Miami River subwatershed (Table 6.2).

Table 6.2. Stream/road crossings in the Miami River watershed. Data were calculated using GIS.

Subwatershed	Watershed Area (sq. mi.)	Road-Stream Crossings (#)	Road-Stream Crossings (#/sq. mi)
Lower Miami River	3.9	18	4.6
Middle Miami River	11.0	32	2.9
Moss Creek	4.6	21	4.6
Upper Miami River	17.2	29	1.7
Total	36.7	100	2.7

6.5 Road Runoff

Water draining from roads can constitute a significant sediment source to streams. However, the amount of sediment potentially contained in road runoff is difficult to quantify, because road conditions and the frequency and timing of use are varied and can change rapidly. Poor road surfaces that are used primarily in dry weather may have a smaller impact on sediment production than roads with high quality surfaces that have higher traffic and are used primarily in the rainy season. Road data were used to assess potential sediment contribution from road runoff. Road density within 200 ft of a stream and on slopes greater than 50 percent was calculated using GIS.

The density of roads within 200 ft of a stream was highest in the Lower Miami River subwatershed, at 0.40 miles of road per mile of stream, while the lowest was in the Middle Miami River, at 0.28 mi/mi. The most common road surface in the Miami River Watershed is gravel, accounting for over three-fourths of all roads in the basin. Dirt roads account for 21% of all roads, and only 2.4% of roads are paved (Table 6.3).

Table 6.3. Current road conditions in the Miami River watershed. The ODF fire roads coverage was used to calculate these numbers in GIS (see GIS data evaluation).

Subwatershed	Stream Length (mi)	Road Length* (mi)	Gravel (%)	Dirt (%)	Paved (%)	Roads <200' from Stream (mi)	(mi/mi**)	Roads <200' from Stream and >50% Slope (% of road length)
Lower Miami River	11.7	20.0	79.6	9.1	11.2	4.7	0.40	3.2
Middle Miami River	28.3	56.2	87.2	5.5	7.3	7.8	0.28	1.1
Moss Creek	12.9	19.3	70.2	29.8	0.0	4.2	0.32	4.4
Upper Miami River	37.4	43.3	76.6	21.0	2.4	10.8	0.29	4.2

* not including railroads or pipeline roads
** miles of road per miles of stream

There are no roads in the Miami River watershed that are both within 200 feet of a stream and on a slope gradient greater than 50%, based on GIS analysis. It must be noted, however, that slope calculations based on Digital Elevation Models (DEMs) tend to under-represent slope steepness.

6.6 Streambank Erosion

Streambank erosion was identified as a critical issue in the lower reaches of Tillamook Bay's main tributary rivers twice in the 1970s (USDA 1978; SSWCC 1972). The conditions noted in both state reports, namely high bank erosion rates and resulting sediment deposition in the Bay, continue to the present day. A study prepared for the Department of Environmental Quality (DEQ) by the SSWCC (1978) identified severe bank erosion along eight miles of the Miami River. This study indicated that streambank erosion in the Tillamook Bay floodplain has been a problem for many years, and has probably contributed greatly to the accumulation of sediment.

Erosion in agricultural lowlands typically takes two forms: streambank cutting, and sheet and rill erosion (Pedone 1995, as cited in Miller and Garono 1995). Streambank erosion is the more prevalent of the two types (USDA 1978). Significant streambank erosion typically takes place due to selective stratigraphic failure, soil saturation, and sloughing during high flow events (USDA 1978). Increased bank erosion is commonly associated with the removal of riparian vegetation. Cattle accessing streambanks can also increase erosion when their hooves break up the soil matrix and remove vegetation (USDA 1978). Sheet and rill erosion are most common along unvegetated road cuts and fills, but also occur on construction sites and roadbeds, and can contribute significant amounts of sediment in localized areas.

Agricultural and urban lowlands occupy approximately 8% of the Tillamook Bay watershed (USDA 1978). USDA (1978) estimated that 60,613 tons (54,976 metric tons) of sediment enter Tillamook Bay annually. Of that total, 9,010 tons (8,172 metric), or 15%, were determined to be derived from agricultural lands. As in upland streams, non-organic sediment plays an important role in stream channel morphology. Organic sediment, including wood, contributes to channel structure, and to the aquatic habitat and food resources of the fluvial ecosystem. Human uses of the lowlands have affected the rate and character of lowland sedimentation through changes in flooding frequency and size, and by the diking of floodplains and tidal wetlands (in some areas, but primarily not in the Miami River watershed). In addition, channel modification, removal of LWD, and streamside grazing have increased streambank erosion. These changes have in turn affected the quantity and quality of riparian and aquatic habitat in the lowlands.

6.7 The Tillamook Burn

The Tillamook Burn fires of 1933, 1939, 1945, and 1956 affected sedimentation rates throughout the watershed for a few decades. Wood inputs and shading were drastically reduced and sedimentation increased by the fires and the subsequent logging and fire control practices that ensued. An earlier study concluded that this disturbance and its attendant increase in sediment production was within the range of natural variation of sedimentation rates through geologic time (LaFrance and McDonald 1995, as cited in Miller and Garono 1995). Active reforestation of the burned areas reduced sediment production rates, and probably has expedited the system's return to lower sediment production rates (LaFrance and McDonald 1995, as cited in Miller and Garono 1995). However, the intensive salvage logging operations which followed the burns, and especially the poor quality roads built through the burned areas (*i.e.*, undersized culverts, log culverts, and extensive sidecasting of materials are examples of the poor techniques used), worsened the sedimentation which followed the fires (Coulton et al. 1996). The Federal Emergency Management Agency (FEMA) acknowledged in 1990 that many landslides which occurred that year originated from salvage roads built between 1940 and 1960 (Coulton et al. 1996).

6.8 Conclusions

Sediment in the rivers and streams of the Miami River watershed has been an issue of concern for many decades. The combination of the wet climate, steep slopes in the uplands, and very erosive soils results in naturally high levels of sediment in the rivers and streams. The historic wildfires in the watershed, as well as resource management practices over the past century have been associated with additional increases in sediment levels. High levels of sediment in the streams have been associated with increased rates of sedimentation in Tillamook Bay. Additionally, high sediment levels are associated with the declining health of salmonid populations. While naturally occurring sources of sediment in the watershed may be uncontrollable (and perhaps to some degree beneficial), the additional sediment contributed by human activity have adverse effects on in-stream habitat quality.

The Miami River watershed lacks a comprehensive landslide inventory. While the rate of landslide activity is probably fairly high, without a survey of landslides it is impossible to determine the frequency or spatial distribution of landslides in the watershed. Previous assessments of sediment in the Tillamook Bay watershed have suggested that landslides and debris flows contribute the majority of the sediment to stream systems in the watershed.

Roads are the primary source of sediment related to human activity. Contribution of sediment from roads is attributed to two processes: landslides originating from roads, and road runoff. Landslides coming from roads produce the largest proportion of road-associated sediment. The high density of stream-crossing culverts and sidecast dirt and gravel roads indicates that road-associated landslides are of significant concern in the Miami River watershed. The ODF road inventory, when complete, will provide detailed road information on ODF lands, which constitute the majority of the gravel and dirt roads in the Miami River watershed. Additionally, cooperation with private landowners to identify and improve sediment sources on private roads will further mitigate the impact of sediment in the watershed.

Lastly, streambank erosion is a concern in the Miami River watershed. While the overall contribution of sediment from streambank erosion is less significant that other sources, erosion from the streambank is associated with a lack of riparian shade. Restoration of riparian vegetation and prevention of livestock grazing near streambanks will lessen sediment contribution from streambank erosion.

CHAPTER 7. WATER QUALITY

7.1 Introduction

The purpose of the water quality assessment, according to the OWEB manual (WPN 1999), is to complete a screening-level analysis of water quality. A screening-level analysis serves to identify obvious areas of water quality impairment by comparing selected measurements of water quality to certain evaluation criteria. The screening-level analysis uses existing data obtained from a variety of sources. This assessment does not include statistical evaluation of seasonal fluctuations or trends through time, and does not evaluate specific sources of pollution through upstream/downstream comparisons.

7.1.1 Assessment Overview

The water quality assessment proceeds in steps. The first step is to identify uses of the water that are sensitive to adverse changes in water quality, and identify potential sources of pollution in the watershed. The second step establishes the evaluation criteria. The third step examines the existing water quality data in light of the evaluation criteria. Conclusions can then be made about the presence of obvious water quality problems in the watershed, and whether or not additional studies are necessary.

Water quality is evaluated by comparing key indicators against evaluation criteria. Indicators are selected to represent pollution categories. Some aspects of water quality, such as fine sediment and temperature processes, are addressed in other sections of this watershed assessment. Although there are many constituents that contribute to the water quality of a stream, the watershed assessment is focused on seven that are most often measured, and that may have the most direct effect on aquatic organisms: temperature, dissolved oxygen, pH, nutrients, bacteria, turbidity, and chemical contaminants. Evaluation criteria, discussed in Section 7.4, have been determined based on values of these constituents that are generally protective of aquatic life.

7.1.2 Components of Water Quality

Temperature

Cool water temperatures are necessary for the survival and success of native salmon, trout, and other aquatic life. Excessively warm temperature can adversely affect the survival and growth of many native species. Although there is some debate about which specific temperatures should apply, and during which part of the year, standards have been set that can be used to determine if the waters in the stream are too warm. Because temperature in the stream varies throughout the day and among the seasons, multiple measurements throughout the day and in different seasons are needed to adequately assess water temperature conditions.

Dissolved oxygen

Aquatic organisms need oxygen to survive. Oxygen from the air dissolves in water in inverse proportion to the water temperature. Warmer water contains less dissolved oxygen at saturated conditions. Organisms adapted to cool water are also generally adapted to relatively high dissolved oxygen conditions. If the dissolved oxygen is too low, the growth and survival of the organisms is jeopardized. As with temperature, dissolved oxygen can vary throughout the day and among the seasons, so multiple measurements, both daily and seasonally, are required for an adequate analysis of water quality conditions.

pH

The pH is a measure of the acidity of water. The chemical form and availability of nutrients, as well as the toxicity of pollutants, can be strongly influenced by pH. Pollutants can contribute to changes in pH, as can the growth of aquatic plants through photosynthesis. Excessively high or low pH can create conditions toxic to aquatic organisms.

Nutrients

Nitrogen and phosphorus, the most important plant nutrients in aquatic systems, can contribute to adverse water quality conditions if present in too great abundance. Abundant algae and aquatic plant growth that results from high nutrient concentration can result in excessively high pH and low dissolved oxygen, can interfere with recreational use of the water, and, in some cases, can produce toxins harmful to livestock and humans.

Bacteria

Bacterial contamination of water from mammalian or avian sources can cause the spread of disease through contaminated shellfish, contact recreation or ingestion of the water itself. Bacteria of the coliform group are used as an indicator of bacterial contamination.

Turbidity

Turbidity is a measure of the clarity of the water. High turbidity is associated with high suspended solids, and can be an indicator of erosion in the watershed. At high levels, the ability of salmonids to see their prey is impaired. As discussed elsewhere, high suspended sediment can have a number of adverse effects on fish and aquatic organisms.

Chemical contaminants

Synthetic organic compounds, pesticides, and metals can be toxic to aquatic organisms. The presence of such contaminants in the water suggests the presence of sources of pollution that could be having an adverse effect on the stream ecosystem.

7.2 Beneficial Uses

The Clean Water Act requires that water quality standards be set to protect the beneficial uses that are present in each water body. The Oregon Department of Environmental Quality (ODEQ) has established the beneficial uses applicable to the 18 major river basins in the State. The Miami River watershed is in the North Coast Basin. The beneficial uses established for all streams and tributaries in the basin are (OAR 340-41-202):

- Public domestic water supply[1]
- Private domestic water supply[1]
- Industrial water supply
- Irrigation
- Livestock watering
- Anadromous fish passage
- Salmonid fish rearing
- Salmonid fish spawning
- Resident fish and aquatic life
- Wildlife and hunting
- Fishing
- Boating
- Water contact recreation
- Aesthetic quality

Estuaries and adjacent marine waters are considered to support the above beneficial uses as well, not including public or private water supply, irrigation, or livestock watering. Water quality must be managed so the beneficial uses are not impaired.

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

7.2.1 Water Uses Sensitive to Water Quality

Not all beneficial uses are equally sensitive to change in water quality. For example, use of the water body for domestic water supply would be impaired long before its use for commercial navigation. In general, water quality is managed to protect the most sensitive beneficial use. In the case of the Miami River watershed, the most sensitive beneficial use is probably salmonid fish spawning. It is assumed that if the water quality is sufficient to support the most sensitive use, then all other less sensitive uses will also be supported.

7.3 Pollutant Sources

7.3.1 Point Sources

The Clean Water Act regulates the discharge of waste to surface water. In order to discharge any waste, a facility must first obtain a permit from the State. ODEQ issues two primary types of discharge permit. Dischargers with Water Pollution Control Facility (WPCF) permits are not allowed to discharge to a water body. Most WPCF permits are issued for on-site sewage disposal systems. Holders of National Pollutant Discharge Elimination System (NPDES) permits are allowed to discharge wastes to waters of the state, directly or indirectly, but their discharge must meet certain quality standards as specified in their permits. Permits set limits on pollutants from industrial and municipal dischargers based on the ability of the receiving stream to absorb and dissipate the pollutants. Industries, municipal wastewater treatment facilities, fish hatcheries, and similar facilities typically have NPDES permits. General permits (GEN) are issued to certain categories of discharger rather than to individual facilities. There are currently no permitted discharges in the Miami River watershed

7.3.2 Non-point Sources

The largest source of water pollution comes from surface water runoff, often called "non-point source" pollution. Rainwater, snowmelt, and irrigation water flowing over roofs, driveways, streets, lawns, agricultural lands, construction sites, and logging operations carries more pollution, such as nutrients, bacteria, and suspended solids, than discharges from industry.

Land use can have a strong influence on the quantity and quality of water flowing from a watershed. An undisturbed watershed with natural vegetation in and along streams and rivers and a diversity of habitats on the uplands provides clean water that supports the desirable beneficial uses of the waterway. As the watershed is affected by activities such as logging, agriculture, and urban development, the water quality in the waterways can become degraded. The percent of the land area of the Miami River watershed affected by these land uses is shown in Table 7.1. Table 1.5 shows the distribution of all land use types in the watershed. Table 1.6 lists possible water quality effects from various types of land use.

Table 7.1. Percent area of the Miami River watershed by selected land uses.

Land Use Type	Area (sq mi)	Percent of Total Area
State Forest	21.5	59.76
Private Industrial Forest	11.8	32.66
Agriculture	0.6	1.75
Developed	<0.1	0.01
Other	2.1	6.83

The most prominent type of land use in the Miami River watershed is forestry, with relatively little land in developed areas. This land use pattern suggests that water quality problems associated with toxic industrial chemicals may be of relatively little importance while problems associated with sediment, turbidity, temperature, and possibly bacteria are likely to be more important. To the extent that herbicides and pesticides are used in forestry and agriculture operations, these compounds may assume greater importance.

Water quality is affected by the introduction of organic matter to streams. The presence of organic matter increases biochemical oxygen demand, which means less dissolved oxygen is available for aquatic life. The introduction of untreated animal or human waste increases the possibility of bacterial contamination of water, increasing the risk of infection to swimmers and limiting its uses. Eutrophication is the process of enrichment of water with nutrients, mainly nitrogen and phosphorous compounds, which results in excessive growth of algae and nuisance aquatic plants. It increases the amount of organic matter in the water and also increases pollution as this matter grows and then decays. Through photosynthesis, algae and aquatic plants consume carbon dioxide (thus raising pH) and produce an overabundance of oxygen. At night the algae and plants respire, depleting available dissolved oxygen. This results in large variations in water quality conditions that can be harmful to other aquatic life. While natural sources of nutrients can influence eutrophication, the introduction of nutrient pollution strengthens the process.

Sources of nutrients include wastewater treatment facility discharge and faulty septic systems, runoff from animal husbandry, fertilizer application, urban sources, and erosion. High water temperatures compound the decline in water quality by causing more oxygen to leave the water and by increasing the rate of eutrophication. Removal of streamside vegetation, among other factors, influences high stream temperature and, via erosion, increases sedimentation of streams.

7.3.3 Water Quality Limited Water Bodies

Sometimes, applying the best available treatment technology to all the point sources in a basin does not bring the stream into compliance with water quality standards. The combination of pollutants from all sources, point and non-point, within the watershed may contribute more pollution than the stream can handle. Under this circumstance, when a stream consistently fails to meet water quality standards for a particular pollutant, it is declared by ODEQ to be "water quality limited" as required by the Clean Water Act Section 303(d). Water bodies on the "303d List" must be analyzed to determine the total amount of pollutant that can be accommodated by the stream (the total maximum daily load – TMDL). This load is then allocated to all the dischargers, including non-point. Dischargers must then take the steps necessary to meet their allocated load. The water quality limited water bodies in the Miami River watershed are listed in Table 7.2.

Table 7.2. Water quality limited water bodies in the Miami River watershed (DEQ 1999).

Water Body	Segment	Parameter	Season
Miami River	Mouth to Stuart Creek	Bacteria	All year
Miami River	Mouth to Moss Creek	Temperature	Summer

7.3.4 Oregon Water Quality Index

Although the 303(d) list identifies water bodies that are known not to meet current water quality standards, the list is not necessarily a complete indicator of water quality in a particular basin. For many stream reaches, there are not enough data to make a determination. In addition, the 303(d) listing is tied to the total amount of monitoring done, which is influenced by the number of special monitoring studies completed by ODEQ. Because special studies are frequently concentrated where water quality degradation is a concern, the list is weighted toward poorer quality waters. Consequently the ODEQ has developed the Oregon Water Quality Index (OWQI) as a water quality benchmark that is keyed to indicator sites monitored regularly by ODEQ.

The OWQI integrates measurements of eight selected water quality parameters (temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia+nitrate nitrogen, total phosphates, total solids, fecal coliform) into a single index value that ranges from 10 (the worst) to 100 (the best). Land use, geology, hydrology, and water quality varies widely throughout the North Coast basin. Water quality data were collected by the ODEQ laboratory in 1985-1987 for the Tillamook Bay Tributaries special study, and regular quarterly ambient monitoring of all of the sites began in 1992. Comparing minimum seasonal Oregon Water Quality Index (OWQI) values (Table7.3), water quality ranges from fair to good at the Miami River site.

Table 7.3. Seasonal Average OWQI Results for the North Coast Basin (WY 1986 -1995).

Site	STORET Number	River Mile	Summer Average	FWS Average	Minimum Seasonal Average
Miami R. @ Moss Ck. Rd.	412120	1.7	81	86	81
Wilson R. @ HWY 6	412133	8.5	91	90	90
Wilson R. @ HWY 101	412130	1.8	82	82	82

Summer: June - September; FWS (Fall, Winter, & Spring): October -May
Scores - Very Poor: 0-59, Poor: 60-79, Fair: 80-84, Good: 85-89, Excellent: 90-100

7.3.5 Data Sources

In order to assess more adequately the water quality conditions in the Miami River watershed, we assembled available data from a variety of sources. Data were obtained from the EPA STORET[2] database for the period 1965 through 1999. In addition, a number of studies conducted and documents prepared under the auspices of the Tillamook Bay National Estuary Program (TBNEP) were reviewed to obtain water quality information for this assessment. They included the *Tillamook Bay Environmental Characterization* report (Hinzman and Nelson 1998), the *Tillamook Bay Comprehensive Conservation and Management Plan* (TBNEP 1999), *Results of Storm Sampling in the Tillamook Bay Watershed* (Sullivan et al. 1998b), *Oregon Coast Range Macroinvertebrate Analysis and Monitoring Status* (Canale 1999), *Water Quality Monitoring in the Tillamook Watershed* (Sullivan et al. 1998a), and the Tillamook Bay TMDL analysis by ODEQ.

[2] STORET data are available on CD-ROM from Earth Info, Inc. 5541 Central Ave., Boulder, CO 80301; (303) 938-1788.

7.4 Evaluation Criteria

The evaluation criteria used for the watershed assessment are based on the Oregon Water Quality Standards for the North Coast Basin (ORS 340-41-205) and on literature values where there are no applicable standards, as for example, for nutrients (WPN 1999). They are not identical to the water quality standards in that not all seasonal variations are included. The evaluation criteria are used as indicators that a possible problem may exist. The evaluation criteria are listed in Table 7.4.

Table 7.4. Water quality criteria and evaluation indicators (WPN 1999).

Water Quality Attribute	Evaluation Criteria
Temperature	Daily maximum of 64° F (17.8° C) (7-day moving average)
Dissolved Oxygen	8.0 mg/L
pH	Between 6.5 to 8.5 units
Nutrients Total Phosphorus Total Nitrate	 0.05 mg/L 0.30 mg/L
Bacteria	Water-contact recreation 126 *E. coli*/100 mL (30-day log mean, 5 sample minimum) 406 *E. coli*/100 mL (single sample maximum) Marine water and shellfish areas 14 fecal coliform/100 mL (median) 43 fecal coliform/100 mL (not more than 10% of samples)
Turbidity	50 NTU maximum
Organic Contaminants	Any detectable amount
Metal Contaminants Arsenic Cadmium Chromium (hex) Copper Lead Mercury Zinc	 190 µg/L 0.4 µg/L 11.0 µg/L 3.6 µg/L 0.5 µg/L 0.012 µg/L 32.7 µg/L

The water quality evaluation criteria are applied to the data by noting how many, if any, of the water quality data available for the assessment exceed the criteria. If sufficient data are available, a judgement is made based on the percent exceedence of the criteria as shown in Table 7.5. If insufficient data are available, it is noted as a data gap to be filled by future monitoring. If any water quality parameter is rated as “moderately impaired” or “impaired”, water quality in the stream reach in question is considered impaired. The condition that caused the impairment should be addressed through stream restoration activities.

Table 7.5. Criteria for evaluating water quality impairment (WPN 1999).

Percent of Data Exceeding the Criterion	Impairment Category
Less than 15 percent	No impairment
15 to 50 percent	Moderately impaired
More than 50 percent	Impaired
Insufficient data	Unknown

7.5 Water Quality Data

7.5.1 STORET

Data were obtained from the EPA STORET database for the period 1965 through 1998. There were 354 sites in the USGS hydrologic unit 17100203, which includes the Wilson, Miami, and several other rivers in the ODEQ North Coast basin, that had water quality data in the STORET database. Of these 354 sites, 83 were from stream monitoring stations in the Miami and Wilson Rivers. The remaining sites were from such locations as point discharges, wells, sewers, pump stations, and similar locations. The ambient water quality sites were distributed among the two watersheds as shown in Table 7.6.

Table 7.6. The distribution of STORET ambient stream water quality sampling sites in the Oregon North Coast basin 1965-1999.

Description	Wilson River Watershed	Miami River Watershed
Total ambient sites	65	18
Number of sites sampled more than once	37	15
Number of sites sampled more than once since 1989	22	10

Sites sampled only once over a period of 30 years do not provide adequate data to make judgements about water quality. Likewise data from more than ten years ago may not be representative for current conditions. For these reasons only sites that had been sampled since 1989 and had been sampled multiple times were used in this analysis. This is consistent with the practice of ODEQ in establishing the Oregon Water Quality Index.

The ambient sites sampled more than once in the Miami River watershed are listed in Table 7.7 and displayed in Figure 7.1.

Table 7.7. Ambient water quality sampling sites used for water quality assessment in the Miami River watershed (EPA 2000).

Station	First	Last	No. Samples	No. Tests	Location	N. Latitude	W. Longitude
405576	4/4/97	5/28/97	16	120	Miami River @ 2nd Br. On Miami R. Forest Rd.	45:37:52	123:48:22
405645	3/10/97	3/12/97	3	40	Miami River D/s Mouth of Moss Creek	45:33:56	123:52:50
405902	11/17/97	11/17/97	12	63	Miami River 300 Yds. D/s of Moss Cr. Rd. Bridge	45:34:31	123:52:20
412119	11/7/60	10/2/97	109	1764	Miami River at Hwy 101	45:33:36	123:53:30
412120	1/1/01	12/10/97	172	2395	Miami River at Moss Creek Road	45:34:31	123:52:20
412180	12/2/79	10/31/89	41	325	Miami River at Stuart Creek Road	45:36:50	123:51:36
412181	12/2/79	3/12/97	49	405	Moss Creek at First Bridge	45:34:14	123:52:10
412219	12/2/79	5/28/97	41	319	Miami River @ 1st Br. On Miami R. Forest Rd.	45:37:19	123:49:24
412221	3/10/80	3/12/97	13	121	Moss Creek at Second Bridge	45:34:05	123:51:38
Til-mm4	8/1/83	3/24/86	26	106	Miami River off Bank on Moss Creek Road	45:34:31	123:52:27

As can be seen in Table 7.7, most of the water quality samples analyzed for the Miami River have been collected at two sites, 412119–at Highway 101–and 412120–at Moss Creek. Relatively few samples, especially for constituents other than temperature, have been analyzed from other locations in the watershed. The water quality assessment will consequently reflect primarily the conditions at these two sites. To the extent that restoration activities depend on knowledge of water quality elsewhere in the watershed, additional data will be required.

7.5.2 ODEQ Sites

ODEQ currently maintains two sites in the Miami River watershed as part of their ambient water quality monitoring network. Table 7.8 shows a numerical summary of grouped data from all the STORET sites with more than one sample in the Miami River for the parameters under consideration in this assessment.

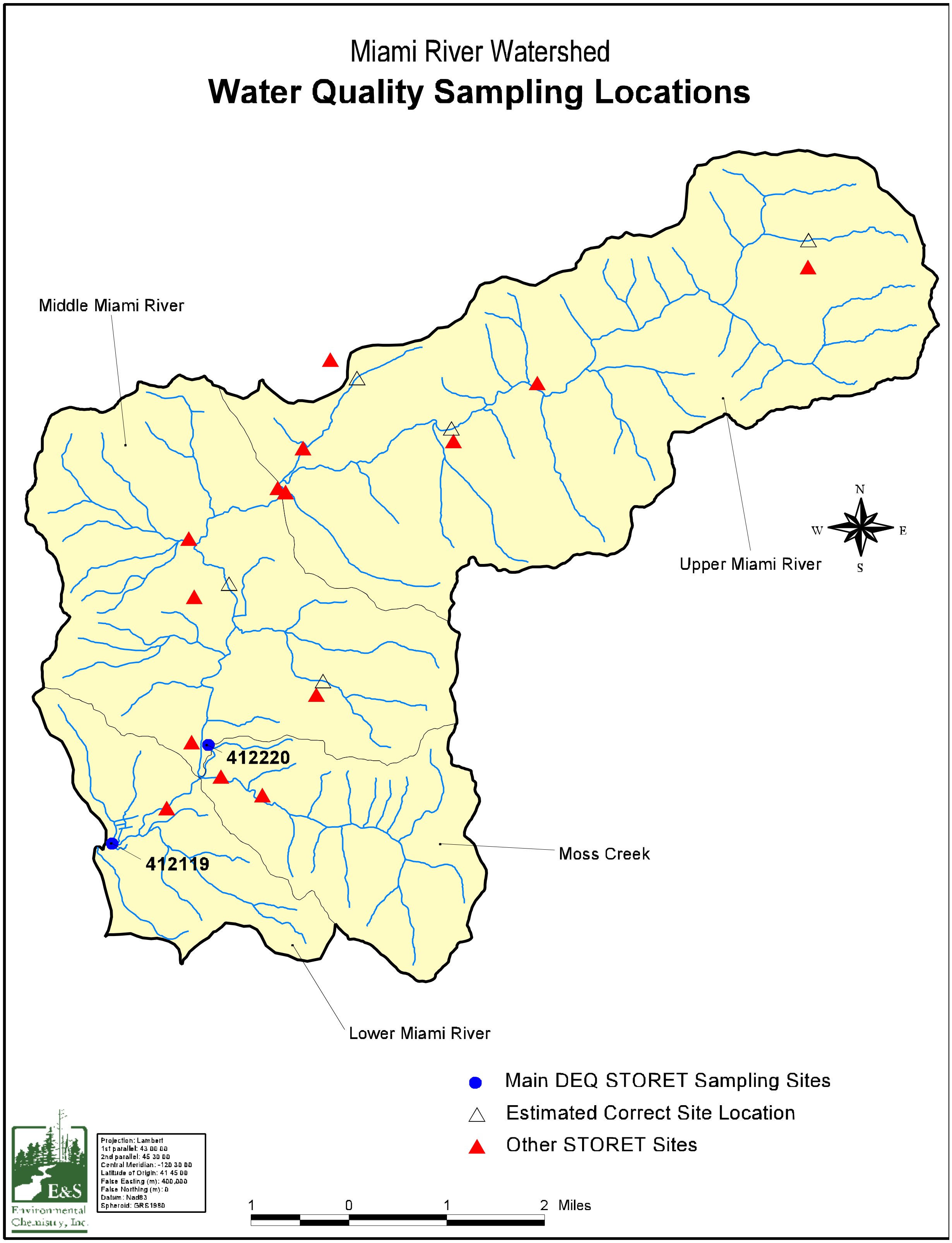


Figure 7.1. Water quality sampling sites in the Miami River watershed in the STORET database. Site descriptions are provided in Table 7.7. For some sites, the sample location in the database does not correspond with a stream location. In such cases, we indicated the most probable correct location for the sampling site.

Table 7.8. Numerical data summary for water quality parameters: Miami River Watershed STORET sites.

Descriptors	Temp (C)	DO (mg/L)	pH	Tot. P (mg/L)	NO_3-N (mg/L)	FCB[4] (#/100 mL)	*E. Coli* (#/100 mL)	Turbidity (NTU)
No. of Observations	931	705	675	184	91	394	30	154
Minimum	0.5	7.7	6	0.01	0.05	0	4	1
Maximum	20	13.7	8.2	0.504	2	46000	1160	45
Mean	12.73	9.32	6.89	0.03	0.75	722	102	3.06
Standard dev.	3.03	1.06	0.24	0.05	0.26	2848	219	5.02
1st quartile[1]	10.5	8.4	6.74	0.012	0.57	30	4	1
Median[2]	13.1	9.1	6.81	0.02	0.73	105	24	2
3rd quartile[3]	15.1	9.9	7	0.0292	0.85	417.5	92	3
Std dev of mean	0.10	0.04	0.01	0.00	0.03	143	40.12	0.40

[1] 25 percent of values were less than or equal to the 1st quartile value
[2] 50 percent of values were less than or equal to the median value
[3] 75 percent of values were less than or equal to the 3rd quartile value
[4] FCB = fecal coliform bacteria

7.5.3 Other Data Sources

Sullivan et al. (1998a,b) collected water quality data from the five major rivers entering Tillamook Bay. The results of this monitoring in 1997 are presented in Table 7.9.

Table 7.9. Flow-weighted average concentration of water quality parameters measured during1997 at the lower watershed site on each of the five rivers (the number of samples is in parentheses).

	Flow Weighted Average Concentration				
Parameter	Tillamook[1]	Trask[1]	Wilson	Kilchis	Miami
Fecal Coliform Bacteria (cfu/100ml)	523 (41)	169 (26)	152 (34)	36 (32)	124 (32)
NH_4-N (mg/L)	0.02 (20)	0.02 (18)	0.02 (19)	0.02 (20)	0.02 (20)
NO_3-N (mg/L)	0.78 (21)	0.82 (19)	0.59 (20)	0.73 (21)	0.93 (21)
Conductivity (µS/cm)	56 (32)	66 (13)	50 (27)	44 (24)	52 (22)
pH	6.6 (15)	7.0 (22)	7.0 (14)	6.9 (15)	6.9 (15)
TSS (mg/L)	38 (24)	137 (19)	253 (23)	86 (24)	60 (24)
TKN (mg/L)	0.31 (21)	0.25 (19)	0.22 (20)	0.24 (21)	0.27 (21)
TP (mg/L)	0.11 (21)	0.25 (4)	0.52 (19)	0.22 (20)	0.15 (21)
Ca (mg/L)	3.1 (4)	7.2 (4)	7.8 (4)	4.3 (4)	3.97 (4)
Mg (mg/L)	1.5 (4)	4.3 (4)	7.4 (4)	2.8 (4)	2.1 (4)
Na (mg/L)	4.0 (4)	3.9 (4)	3.4 (4)	2.9 (4)	3.6 (4)
K (mg/L)	0.614 (4)	0.32 (4)	0.47 (4)	0.20 (4)	0.27 (4)
SO_4-S (mg/L)	0.62 (4)	0.61 (4)	0.49 (4)	0.29 (4)	0.35 (4)
Cl (mg/L)	6.5 (4)	3.2 (4)	2.7 (4)	3.3 (4)	5.0 (4)

[1] Data collected for the Tillamook and Trask Rivers during an intensively monitored storm event in October, 1997 were excluded from this analysis because comparable data were not available for the other three rivers.

7.6 Water Quality Constituents

7.6.1 Temperature

Of the 345 individual temperature measurements taken at the sites in the Miami River watershed, six (1.7 percent) exceeded the evaluation criterion of 17.8 °C (64° F). These data are presented in Figure 7.2. In 1995 ODEQ measured temperature in the Miami River at Moss Creek Road (Site 412120) at 15-minute intervals during the summer. During this period, the 7-day average of daily maximum temperature was 20.8° C (69.5° F), and 17 days exceeded the evaluation criterion of 17.8° C (64° F). These data are what led to the Miami River being included on the 1998 303(d) list of water quality limited streams. A subset of the ODEQ data is shown in Figure 7.3 to show the diurnal variation.

The TMDL established by ODEQ for temperature in the basin will set targets for shade development that should result in a reduction in water temperatures. To gauge progress, temperature monitoring stations have been established at two sites, at Stewart Creek Bridge for salmonid migration and rearing (June through September) and at Moss Creek Road for spawning (May through October).

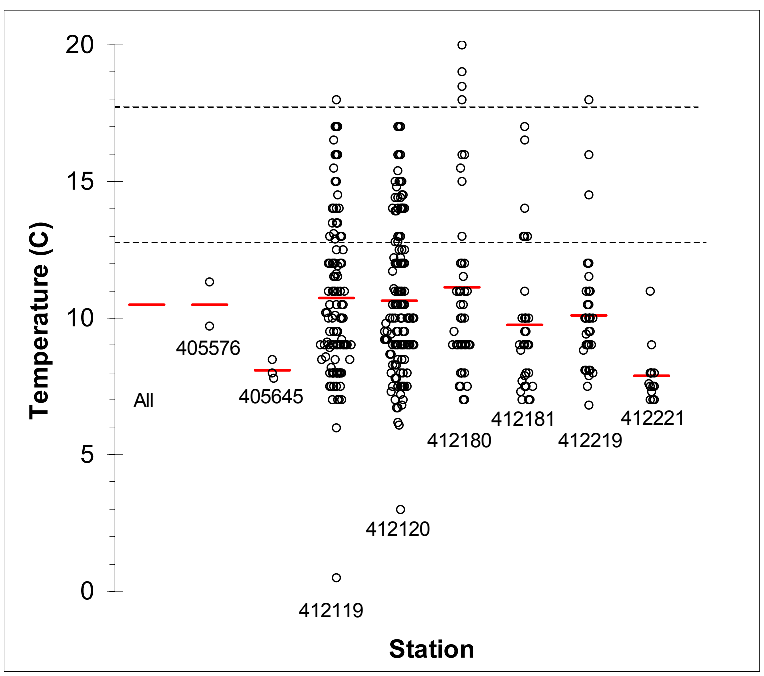


Figure 7.2. Scatter diagram of temperature observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed lines show the evaluation criteria of 12.8º C and 17.8º C. Site descriptions can be found in Table 7.7.

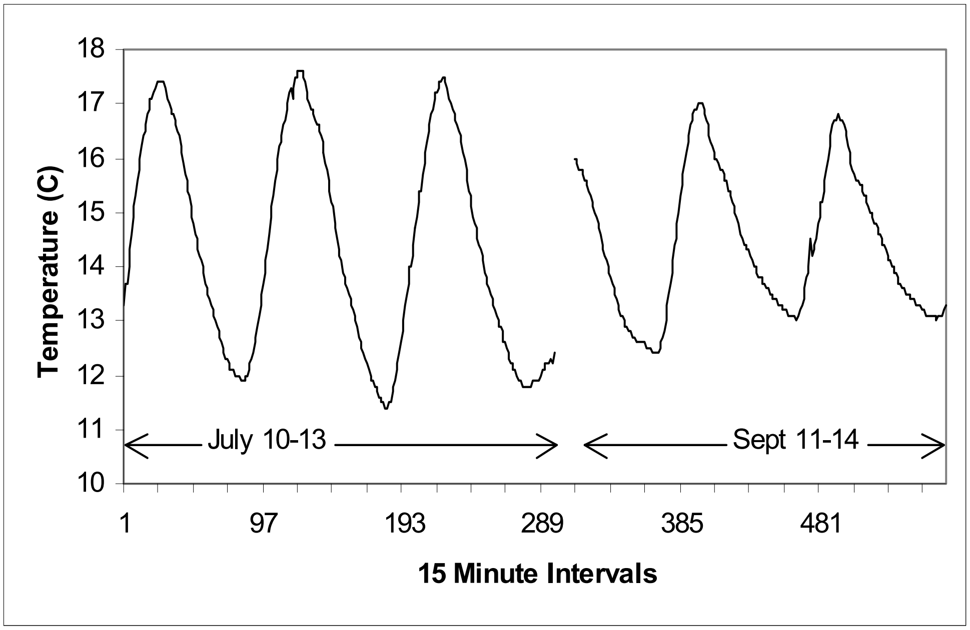


Figure 7.3. Temperature data collected at 15-minute intervals in the Miami River at Moss Creek (412120) during two time periods in 1995 (data from STORET). Maximum temperatures occurred between 3:00 and 5:00 PM, minimum temperatures between 7:00 and 8:00 AM.

7.6.2 Dissolved Oxygen

Individual dissolved oxygen measurements taken over time are presented in Figure 7.4. Of the 136 available measurements, only one was less than the evaluation criterion of 8.0 mg/L. When compared to the more stringent standard of 11.0 mg/L, applicable to streams supporting salmonid spawning and incubation, 50 percent of the measurements taken are less than the standard. ODEQ measured dissolved oxygen at 15-minute intervals during several days in the summer of 1995. Some of those data are presented in Figure 7.5. Even though dissolved oxygen showed a fairly large daily variation, values never dipped below 8.0 mg/L.

These results indicated that the Miami River is not impaired with respect to dissolved oxygen.

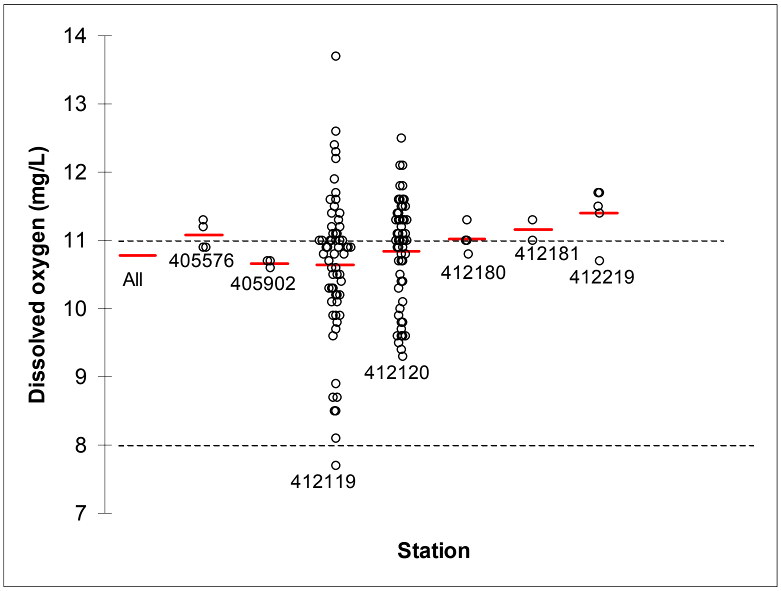


Figure 7.4. Scatter diagram of dissolved oxygen observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed lines show the evaluation criteria of 8 mg/L and 11 mg/L. Site descriptions can be found in Table 7.7.

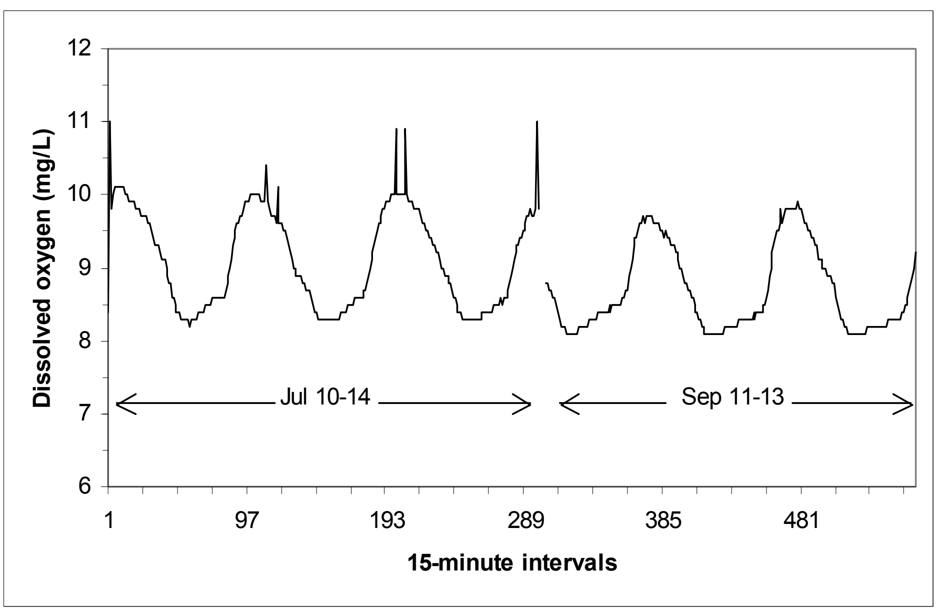


Figure 7.5. Dissolved oxygen data collected at 15-minute intervals in the Miami River at Moss Creek (412120) during two time periods in 1995 (data from STORET). Maximum dissolved oxygen occurred between 11:00 AM and 1:00 PM, minimum dissolved oxygen between 2:00 and 5:00 AM.

7.6.3 pH

None of the 287 individual measurements of pH were greater than the upper criterion value of 8.5, and only 12 measurements (4.2 percent) were less than the lower criterion value of 6.5 (Figure 7.6). A few values of pH less than 6.5 should not be of concern in the Miami River. Because it is a coastal watershed heavily dominated by rainfall during the winter, pH values can be expected naturally to be near 6.0 to 6.5 on occasion. Diurnal measurements of pH by ODEQ in 1995 show that pH exhibits a relatively narrow daily range of less than 0.5 pH units (Figure 7.7).

The Miami River is not impaired with respect to pH.

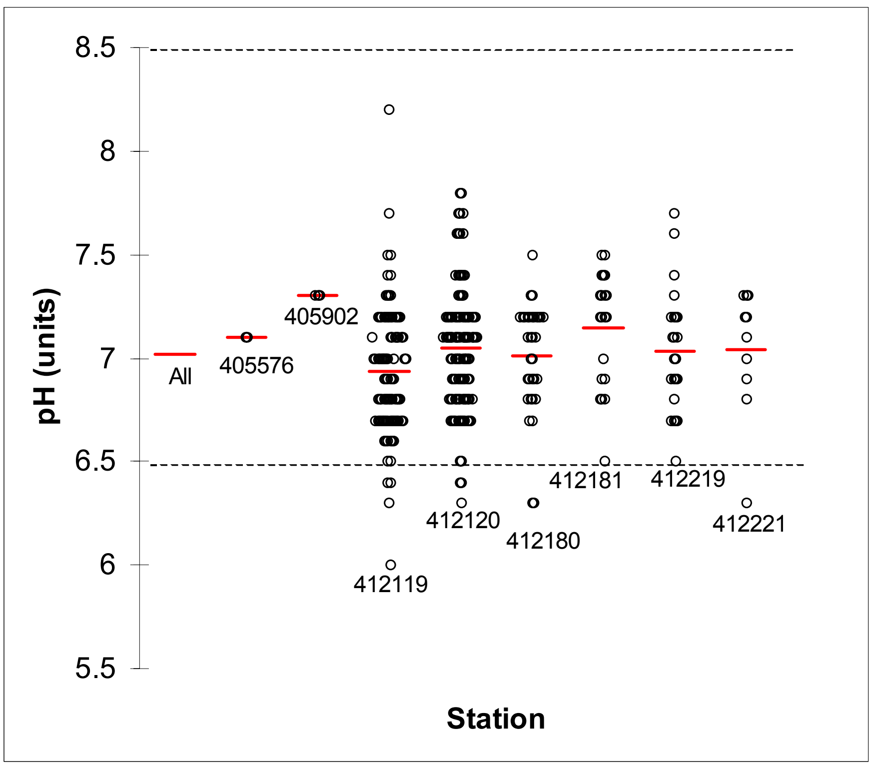


Figure 7.6. Scatter diagram of pH observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed lines show the evaluation criteria of 6.5 and 8.5. Site descriptions can be found in Table 7.7.

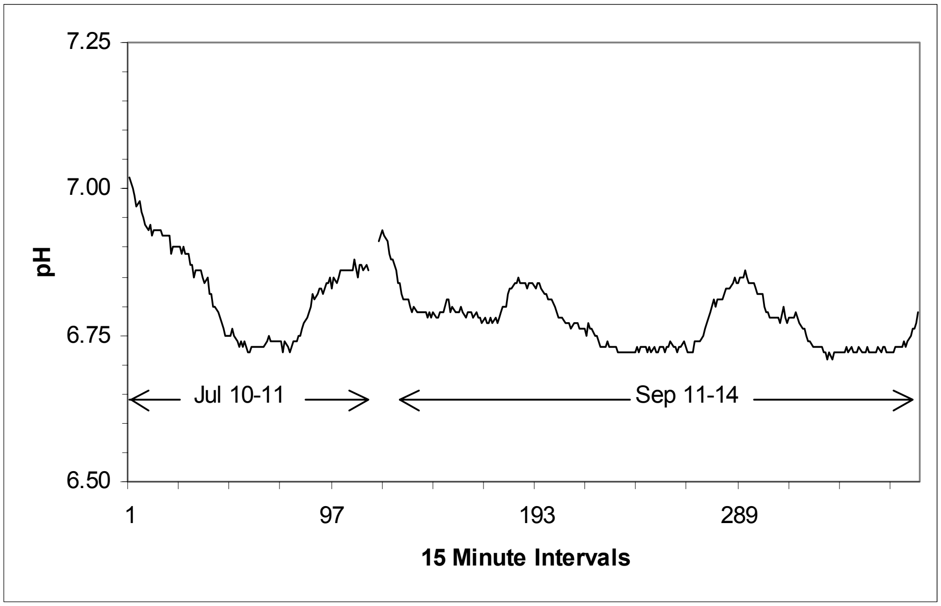


Figure 7.7. pH data collected at 15-minute intervals in the Miami River at Moss Creek (412120) during during two time periods in 1995 (data from STORET). Maximum pH occurred during mid afternoon, minimum pH during early morning, just prior to sunrise.

7.6.4 Nutrients

There is currently no applicable state water quality standard for phosphorus or nitrogen. The criterion values of 0.05 mg/L for phosphorus and 0.3 mg/L for nitrogen are based on concentrations that have been associated with water quality problems in other water bodies.

Phosphorus

Ninety water samples from the Miami River basin have been analyzed for total phosphorus. Of these, 7 (7.8 percent) exceeded the evaluation criterion of 0.05 mg/L (Figure 7.8). The Miami River is not impaired with respect to phosphorus.

Nitrogen

There have been 89 samples analyzed for nitrate-nitrogen in the Miami River basin. Of these, 87 (98 percent) exceeded the evaluation criterion of 0.3 mg/L (Figure 7.9). Regression analysis of the nitrate-nitrogen data shows that nitrogen concentration in the Miami River has been increasing during the period of record (Figure 7.10). These data suggest that there is a source of nitrogen in the watershed contributing to these high values. It might be expected that

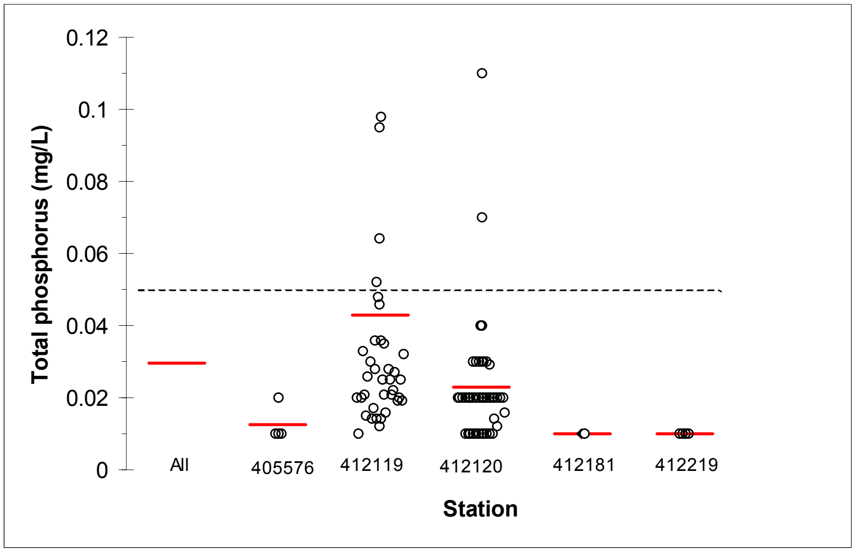


Figure 7.8. Scatter diagram of total phosphorus observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed line shows the evaluation criterion of 0.05 mg/L. Site descriptions can be found in Table 7.7.

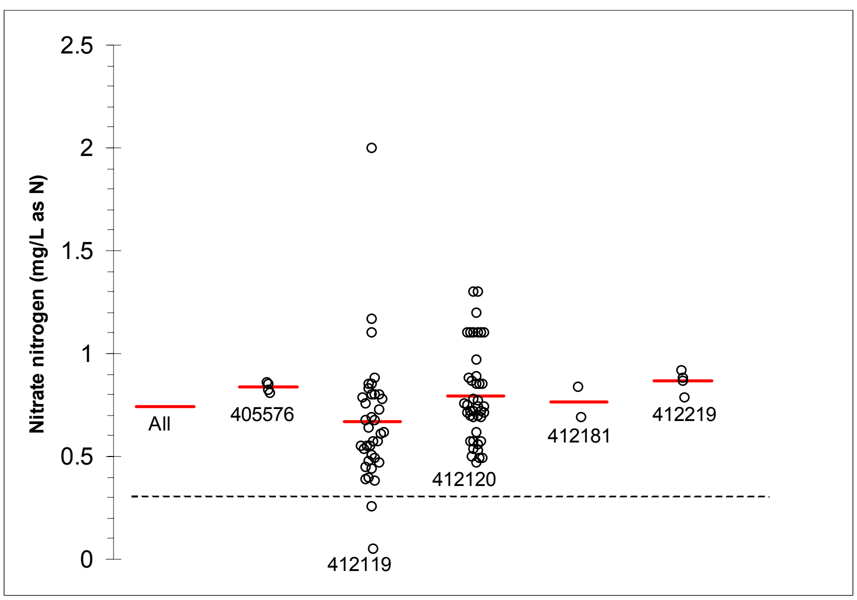


Figure 7.9. Scatter diagram of nitrate-nitrogen observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed line shows the evaluation criterion of 0.3 mg/L. Site descriptions can be found in Table 7.7.

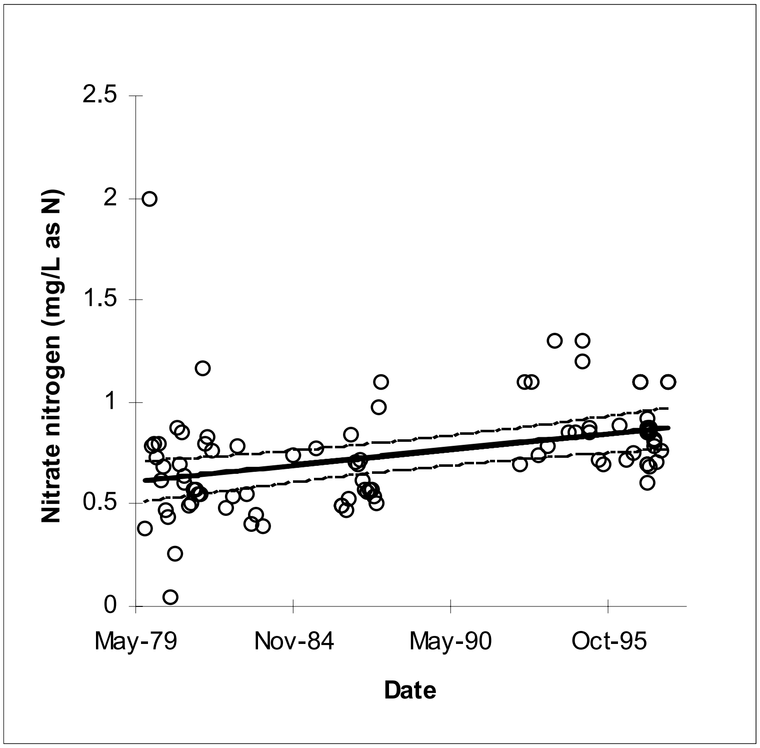


Figure 7.10. Nitrate-nitrogen data from the Miami River basin showing the calculated regression line with 95% confidence limits. The regression line has a statistically significant positive slope ($P<0.01$) indicating that nitrate concentration in the Miami River is increasing through time.

nonpoint source runoff from fertilized agricultural lands would be a contributing factor, however, agricultural land is such a small portion of the watershed that this seems unlikely. It is also possible that the relatively high nitrate values are related to forestry activities in the watershed.

Alder trees can be a significant source of nitrogen in coastal forests. Bacteria associated with alder roots can convert nitrogen gas from the atmosphere, which is essentially inert, to nitrate compounds which can be used for growth by vegetation. Because of past forestry practices in the Miami watershed, there is an unusually high abundance of alder trees associated with the riparian zones of the streams in the watershed. It is possible that these alder contribute to the high concentration of nitrogen in the streams. Additional sampling would be required, perhaps above and below Prouty Creek, to verify this.

The Miami River watershed could be considered impaired with respect to nitrogen.

7.6.5 Bacteria

Tillamook Bay has a long history of bacterial pollution problems (Blair and Michener 1962, Jackson and Glendening 1982, Musselman 1986), During the 1980's, major bacterial sources were identified and various measures were taken to decrease bacterial pollution. Important sources of fecal coliform bacteria have been identified as discharge from wastewater treatment plants, runoff from agricultural areas, discharge from malfunctioning septic systems, and direct input from animals in the basin (Jackson and Glendening 1982). More recent reports on water quality in the Tillamook Basin have suggested that bacterial concentrations have decreased, although water quality violations still occur (Arnold et al. 1989). These data, however, were perceived to be biased due to sampling in different water years and later studies were performed to test for trends in the water quality data set. Statistical tests generally showed a reduction in fecal coliform concentrations (Dorsey-Kramer 1995) although the overall trend analysis was inconclusive (Wiltsey 1990). During this period, the number of dairy cows increased approximately 37% (Commodity Data Sheets 1980 and 1990), suggesting that implemented land use practices were partially effective in reducing fecal coliform contributions to surface waters of the Tillamook Basin.

Water quality standards for recreational contact and shellfish growing waters differ; but standards in both fresh water and the bay have long been violated in the Tillamook Basin (Jackson and Glendening 1982). The bacteria standard for recreational contact applies to both fresh and saline waters and is intended to protect people in contact with water, such as swimmers. The shellfish standard is much more stringent, because it is designed to protect people from pathogens which might be consumed with raw shellfish. Oregon has adopted the water quality standards for bacteria and other pathogens in estuarine water set by the federal Food and Drug Administration (FDA) for interstate commerce (U.S. Dept. of Health and Human Services 1995). Bacterial concentrations in the bay have historically been high during the wet seasons of the year: fall, winter, and early spring.

Fecal Coliform Bacteria

The STORET database included 394 observations of fecal coliform bacteria from seven sites in the watershed. By far the majority of these observations were from the Miami River at Highway 101 and Moss Creek. Of these observations, 269 (68 percent) exceeded the bay criterion of 43 colonies/100 mL, and 334 (85 percent) exceeded the bay criterion of 14 colonies/100 mL (Figure 7.11). The median values at all sites were greater than 14 colonies/100

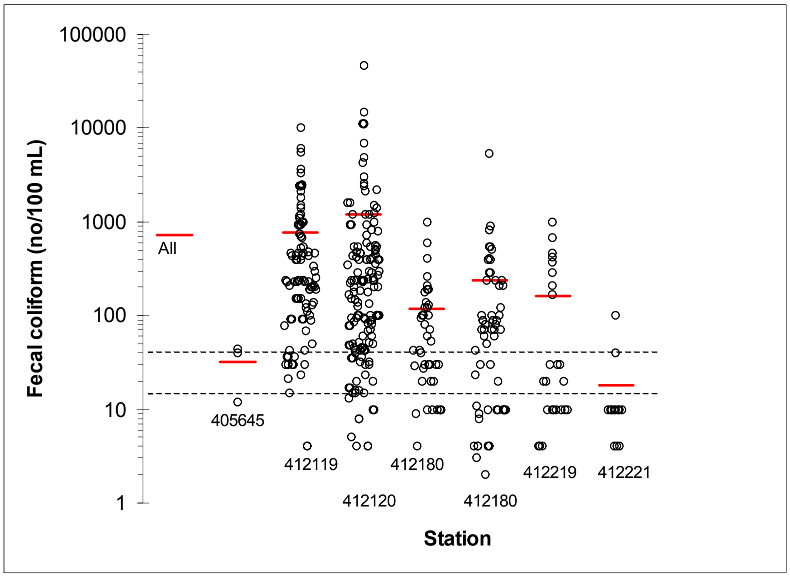


Figure 7.11. Scatter diagram of fecal coliform bacteria observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed lines show the evaluation criteria for bay water of 14 and 43 colonies/100 mL. The freshwater standard was formerly 200 colonies/100 ml; this has recently been changed in favor of *E. coli* standards for fresh water in Oregon. Site descriptions can be found in Table 7.7.

mL with the exception of site 412221 which was 10 colonies/100 mL. This site is in Moss Creek, not the Miami River. It should be noted that these bay criteria are designed to protect the shellfish production beneficial use and are therefore very stringent.

Table 7.10 shows a comparison between the results of fecal coliform bacteria measurements in 1979 and 1980 by Jackson and Glendening (1982) and during the period 1996 and 1997 by Sullivan et al. (1998a). All Miami River data were collected at Moss Creek Bridge and Wilson River data at Sollie Smith Bridge. There is no indication that the percent of samples exceeding the freshwater fecal coliform bacteria standard (200 colonies/100 ml) changed between 1980 and 1997.

E. coli

Of the 30 STORET observations for *E. coli*, the majority from site 412120 in the Miami River at Moss Creek, only one exceeded the single sample maximum criterion of 406 colonies/ 100 mL (Figure 7.12). The average value for *E. coli* at all sites except 412120 is less than the log mean criterion of 126 colonies/100 mL. The log mean is always less than the average, so none of these sites exceeds the criterion. The average value for site 412120 is 206 colonies/100 mL, but the log mean is only 80 colonies/100 mL, so this site is within the criterion as well.

Table 7.10. Comparison of fecal coliform bacteria results in the Wilson and Miami Rivers in 1979-1980 and 1996-1997. Miami River data were collected at Moss Creek Bridge on the mainstem.

River	Percent of samples exceeding criterion value (200 cfu/100 ml) (number of samples collected in parentheses)			
	December		October	
	1979[1]	1996-1997[2]	1980	1997
Wilson	25 (8)	22 (9)	67 (6)	100 (8)*
Miami	63 (8)	50 (10)	88 (8)	-

[1] 1979-1980 data from Jackson and Glendening (1982)

[2] 1996-1997 from Sullivan et al. (1998a)

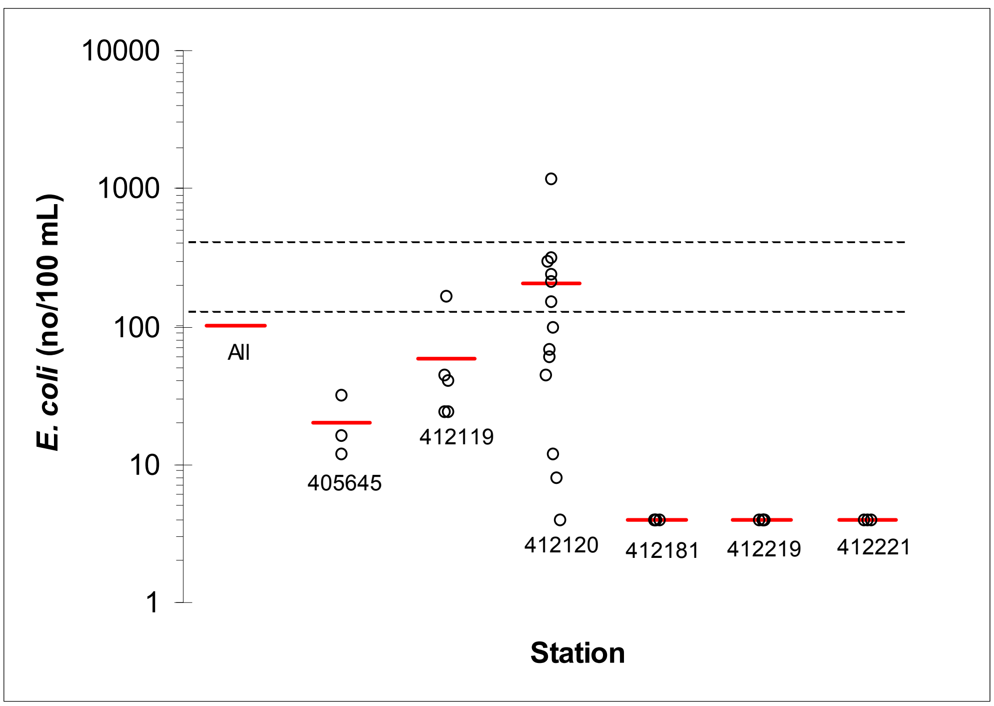


Figure 7.12. Scatter diagram of *E. coli* observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed lines show the evaluation criteria of 126 and 406 colonies/100 mL. Site descriptions can be found in Table 7.7.

E. coli measurements are conducted by the Tillamook County Performance Partnership at six sites on the Miami River. Available data for the period October 1999 through October 2000 indicated that the geomean concentration consistently exceeded 126 colonies/100 ml at three of the sites between May and November.

The Miami River is impaired with respect to bacteria as related to shellfish production, and appears to be at least seasonally impaired with respect to water contact recreation.

7.6.6 Turbidity

None of the 154 observations of turbidity exceeded the evaluation criterion of 50 NTU (Figure 7.13). Turbidity is closely related to suspended sediment in the stream, and thus tends to be highest during periods of high runoff when more sediment is transported to the stream. Because of the nature of the ongoing sampling in the Miami River watershed, with relatively few samples collected during high runoff events, it is likely that the turbidity values in the database do not reflect the true range of turbidity values present in the stream. The data suggest that the Miami River basin is not impaired with respect to turbidity. However, to the extent that sources of excess sediment are identified, it may be necessary to collect additional turbidity measurements to truly characterize conditions in the watershed.

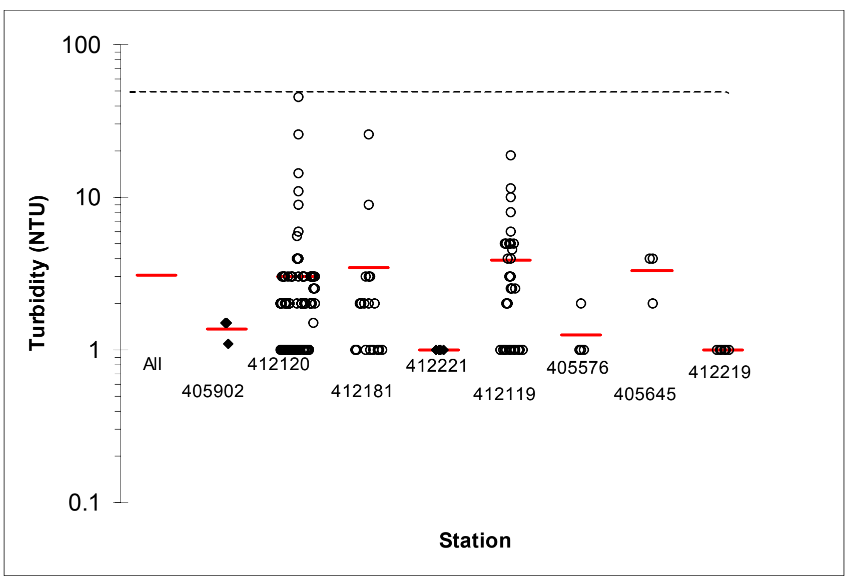


Figure 7.13. Scatter diagram of turbidity observations from several sites in the Miami River basin from 1960 to 1999. The short horizontal lines represent the average for all observations at a site. The horizontal dashed line shows the evaluation criteria 50 NTU. Site descriptions can be found in Table 7.7.

7.6.7 Contaminants

Measured concentrations of trace metals are listed in Table 7.11. These results do not indicate that the Miami River is impaired for trace metals. For many of the observations, the detection limit was greater than the evaluation criterion so it is not possible to say if the criterion was exceeded or not. There is insufficient data to determine the status for organic contaminants. This is a data gap that could be filled by further sampling and analysis.

Table 7.11. Positive results for trace metals obtained in the Miami River.

Element	Screening criterion (µg/L)	Analytical results[1] (µg/L)
Arsenic	190	<5 (2)
Cadmium	0.4	<1 (2)
Chromium (hex)	11.0	<50 (3)
Copper	3.6	5 (3)
Lead	0.5	<10 (3)
Mercury	0.012	not measured
Zinc	32.7	<10 (3)

[1] Highest value recorded. The number of observations is in parentheses. The symbol " < " indicates the value was less than the method detection limit.

7.7 Water Quality Conditions

At the screening level of this assessment, water quality in the major streams of the Miami River watershed would be considered impaired because of the frequency of exceedence of the evaluation criteria for temperature, nitrogen, and bacteria related to shellfish culture in the bay. Dissolved oxygen may also be a problem if salmonid spawning occurs in the lower reaches of the river near the mouth. There is no reason to suspect that the river suffers from impairment with respect to pH, total phosphorus concentration, turbidity, or bacteria related to water contact recreation. There is not sufficient data to make a determination with respect to trace metals or organic contaminants.

Issues with regard to water quality degradation are being addressed through implementation of a coordinated management plan, the TBNEP's Comprehensive Conservation Management Plan (CCMP). Bacteria, temperature, and dissolved oxygen issues can be addressed by stream and watershed restoration activities. In order to adequately address the causes of impairment with respect to nitrogen and toxic contaminants, additional data should be obtained through a carefully designed water quality monitoring program.

CHAPTER 8. WATERSHED CONDITION SUMMARY

8.1 Introduction

Summarizing current conditions and data gaps within the watershed will help to identify how current and past resource management is impacting aquatic resources. Through this summarization, we have attempted to create a decision-making framework for identifying key restoration activities that will improve water quality and aquatic habitats. Following is a summary of key findings and data gaps derived from the primary components of this watershed assessment, including fisheries, fish habitat, hydrology, water use, sediment sources, and water quality.

8.2 Important Fisheries

Fisheries within the Miami River watershed have undergone significant changes during the twentieth century. The types of fish present and their locations and abundance have been altered from historical conditions in the watershed. Arguably, the most significant activities to affect the fisheries during the last one hundred years have been habitat modifications, hatchery programs and harvest.

The National Marine Fisheries Service (NMFS) has listed as threatened, or is considering as candidates for listing, several anadromous fish species in the watershed (Table 8.1). Listing occurs for entire Evolutionarily Significant Units (ESU), defined as genetically or ecologically distinctive groups of Pacific salmon, steelhead, or sea-run cutthroat trout.

Tillamook basin coho salmon, chum salmon, steelhead trout, and sea-run cutthroat trout populations are depressed (TBNEP 1998). At least part of these species' decline can be attributed to recent changes in oceanic conditions that, since about 1975, have been less

Table 8.1. Status of anadromous fish occurring in the Miami River watershed.

Fish	ESU	Status
Coho	Oregon Coast	Threatened
Coastal Cutthroat	Oregon Coast	Candidate
Chum	Pacific Coast	Not Warranted
Chinook	Oregon Coast	Not Warranted
Steelhead	Oregon Coast	Candidate

* An Evolutionarily Significant Unit or "ESU" is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

favorable for the survival of anadromous salmonids along the northern California, Oregon, and Washington coasts. Coho salmon have been particularly hard hit by the poor ocean conditions because they rear off the northern California and Oregon coasts and do not migrate into the more productive waters of the Gulf of Alaska. Overharvesting of coho salmon when ocean conditions were poor exacerbated the problem. Harvest management has been changed recently to adjust for the poor ocean conditions.

Hatchery fish spawning with wild fish may be causing genetic introgression, a significant problem for both coho salmon and steelhead trout in the Tillamook Basin. An observed shift in the spawning timing of naturally spawning coho salmon represents a potentially serious problem that could be contributing to the observed population decline. Although many contributors to the observed decline of anadromous fisheries are well known, the interactions among the various contributing factors are poorly understood. Information gaps for salmonids in the freshwater environment include:

- scientifically designed long-term monitoring programs to measure changes in key habitat variables through time;
- biological measures of habitat condition such as smolt production, density of juveniles per unit area of rearing habitat, and benthic macroinvertebrate abundance; and
- understanding of the amount of genetic mixing that has occurred between hatchery and wild stocks.

Information gaps for salmonids in the estuarine environment include:

- information on the quantity or quality of juvenile salmonid rearing habitat in the estuary;
- information on present use of various major estuarine habitats by juvenile salmonids; and
- long-term monitoring designed to evaluate effects of changes in watershed inputs of sediment, plant nutrients, large woody debris, and toxic substances on estuarine habitat conditions and estuarine biological communities.

The TBNEP (1998) found that very little of the existing information on fisheries populations was developed from statistically designed sampling programs. Inferences regarding population status were often based on potentially biased data. This can be a serious problem, particularly if management decisions such as harvest quotas are based on what may be inaccurate information. It is critical, therefore, that scientifically designed sampling schemes be built into any short-term or long-term sampling program used for the management of the valued resources of the Tillamook Basin.

In addition, reliable long-term monitoring data were not available for all of the valued resources. Without long-term data sets, it is impossible to evaluate trends through time or to separate out effects of natural phenomena from human-induced changes.

Finally, there have been no comprehensive studies relating the condition of the watershed to conditions in the estuary, especially with respect to important impacts on valued resources. We know that many of the changes that have taken place in the estuarine environment are caused by or related closely to disturbances in the watershed that have altered flow, sediment input rates, and water quality. Monitoring and research directed at linking conditions in the watershed to conditions in the estuary are lacking.

8.3 Hydrology and Water Use

8.3.1 Hydrology

Human activities in a watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and aquatic habitats. These types of changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge. Some examples of human activities that can impact watershed hydrology in the Miami River watershed are timber harvesting, alterations to the floodplain, and construction of road networks. The focus of the hydrologic analysis component of this assessment was to evaluate the potential impacts from land and water use on the hydrology of this watershed (WPN 1999). It is important to note, however, that this assessment only provides a screen for potential hydrologic impacts based on current land use activities in the watershed. Identifying those activities that are actually affecting the hydrology of the watershed would require a more in-depth analysis and is beyond the scope of this assessment.

Screening for land management activities that may be affecting natural hydrologic conditions suggests that forests and roads have little effect on current hydrologic regimes (Table 8.2), but other hydrologic impacts may have occurred in response to the Tillamook Burns and/or agricultural practices (especially diking and draining of wetlands) in the valley bottoms. Loss of historical flood plain acreage and land cover (such as wetlands, forested valley bottoms) have likely had some impact on hydrologic conditions in the Miami River watershed.

Table 8.2. Potential effects of land use on peak flows, based on standards established in the OWEB Watershed Assessment Manual.

Subwatershed	Forested	Forest Roads	Rural Roads	Agriculture
Lower Miami River	Low	Low	Low	Insufficient Data
Middle Miami River	Low	Low	Low	Insufficient Data
Moss Creek	Low	Low	Low	Insufficient Data
Upper Miami River	Low	Low	Moderate	Insufficient Data

The documented sensitivity of valley flooding to upstream watershed conditions indicates the need for a strong management focus on maintaining natural watershed functions. Future flood management efforts in the valley floodplains may be obfuscated by the failure to adequately address upland watershed impacts that influence the flow rate and volume of flood waters. However, altered upland processes can be difficult to restore, especially where they are part of a significant disturbance regime such as the Tillamook Burns.

8.3.2 Water Use

Water is withdrawn from both surface and subsurface water supplies within almost all of the watersheds in Oregon. Much of this water is withdrawn for beneficial uses, such as irrigation, municipal water supply, and stock watering. When water is removed, a certain percentage is lost through processes such as evapotranspiration. Water that is "consumed " through these processes does not return to the stream or aquifer, resulting in reduced in-stream flows, which can adversely affect aquatic communities that are dependent upon this water. In fact, seasonal dewatering of streams has often been cited as one of the major reasons for salmonid declines in the state of Oregon.

The water appropriated in the Miami River watershed is for municipal use and irrigation. Most of this water is appropriated in the lower elevations of the watershed. During very dry seasons, domestic water used combined with irrigation withdrawals in the lower elevations of the Miami River watershed may have deleterious effects on in-stream habitats by reducing in-stream flows. However, appropriated water represents only a very small percentage of in-stream flows, suggesting that the impacts are most likely small on average and only occur during dry periods.

Water availability was assessed by rating subwatersheds according to their dewatering potential. All subwatersheds were judged to have low dewatering potential (Table 8.3), which is

Table 8.3. Dewatering potential and associated beneficial uses of water in the Miami River watershed.

Subwatershed	Fish Use	Average Percent withdrawn	Dominant Water Use	Dewatering Potential
Miami River @ 14301300	C, FC, WS, CH, CT	0.4	Municipal	Low
Miami River @ mouth	C, FC, WS, CH, CT	1.3	Municipal	Low
Moss Creek @ mouth	C, FC, WS, CH, CT	0	Municipal	Low
Peterson Creek @ mouth	C, FC, WS, CH, CT	0	–	Low
Prouty Creek @ mouth	C, FC, WS, CH, CT	1.4	Irrigation	Low

[1] C=coho, FC=fall chinook, WS=winter steelhead, CH=chum, CT=cutthroat
[2] Average of low flow months (June, July, August, September, October).
[3] Greater than 30% is high, 10 to 30% is moderate, and less than 10% is low.

defined as the potential for large proportions of in-stream flows to be lost from the stream channel through consumptive use.

Based on current water availability model outputs, there appears to be little concern for dewatering in the Miami River watershed during average or above flows. None of the subwatersheds demonstrated water loss greater than 2% of the predicted in-stream flows. Consequently, it is unlikely that water withdrawals from the Miami River and its tributaries are having a large impact on current in-stream flows. However, any time water is appropriated for out-of-stream use, there is a potential for some effects on the in-stream habitats to occur during periods of very low flow.

8.4 Aquatic Habitats

Distribution and abundance of salmonids within a given watershed varies with habitat condition, such as substrate and pool frequency as well as biological factors such as food distribution (i.e. insects and algae). In addition, salmonids have complex life histories and use different areas of the watershed during different parts of their life cycle. For example, salmonids need gravel substrates for spawning but may move to different stream segments during rearing. The interactions of these factors in space and time make it difficult to determine specific factors affecting salmonid populations. Consequently, entire watersheds, not just individual components, must be managed to maintain fish habitats (Garono and Brophy 1999).

The Endangered Species Act requires that forests providing habitat for endangered species must be protected (Tuchmann et al. 1996). An understanding of the land patterns associated with the distribution of threatened and endangered species can lead to a better understanding of how to conserve these species. The OWEB process focuses primarily on salmonid habitat in the watershed. It is assumed, however, that other species will also benefit.

For some salmonid species such as coho salmon, which require specific overwinter rearing and refuge habitat, habitat conditions may be degraded. For other species, such as fall chinook salmon, which spawn and rear in main stem and larger tributary habitat and do not spend long periods of time in the freshwater environment, habitat conditions appear to be satisfactory**.** One of the biggest habitat-related problems in the watershed is the general lack of LWD in the small- to medium-size tributary streams. The generally poor ratings for LWD recruitment from riparian areas indicate that recovery of habitat complexity in many areas will be a long process due to the lag time required to reestablish conifer communities in the riparian zone. Better management practices have eliminated a number of the man-caused disturbances that have contributed to the present condition of the freshwater habitat. A watershed approach to stream habitat restoration is needed to ensure continued recovery.

Other major problems identified were the general lack of channel complexity and off-channel habitat. Excessive fine sediment in the spawning gravel was identified as a persistent problem in many of the stream reaches surveyed.

To summarize, resource problems for anadromous salmonids include:

- general lack of LWD (and low LWD recruitment potential) and associated channel complexity;
- lack of off-channel habitat for winter refuge and rearing of coho salmon and cutthroat trout; and
- persistent sources of sediment loading.

8.4.1 Fish Passage

Culverts can pose several types of fish passage problems, including excess height, excessive water velocity, insufficient water depth in culvert, disorienting flow patterns, and lack of resting pools between culverts. In some cases, culverts limit fish passage during only certain parts of the species' life cycle. For example, a culvert may be passable to larger adult anadromous fish and not juveniles. Culverts may also act as passage barriers only during particular environmental conditions such as high flow or low flow events. Because of these variable effects, it is important to understand the interactions between habitat conditions and life stage for anadromous fish.

Less than one-fourth of the stream-road crossings in the watershed have been surveyed for culvert condition. Of those surveyed, 43% were judged to constitute fish passage barriers (Table 8.4).

Table 8.4. Fish passage conditions in the Miami River watershed based on ODFW data.

Subwatershed	Stream Length (mi)	Salmonid Use*	Miles Salmonid Use	# Culverts Surveyed	# Known Impassable Culverts	# Road/ Stream Crossings
Lower Miami River	12	C, FC, CH, WS, CT	13.9	11	5	18
Middle Miami River	28	C, FC, CH, WS, CT	26.1	5	2	32
Moss Creek	13	C, FC, CH, WS, CT	7.2	6	2	21
Upper Miami River	37	C, FC, CH, WS, CT	44.7	1	1	29
Total	90		91.9	23	10	100

* C=coho, FC=fall chinook, CH=chum, WS=winter steelhead, CT=cutthroat

8.4.2 Fish Habitats

Understanding the spatial and temporal distribution of key aquatic habitat components is the first step in learning to maintain conditions suitable to sustain salmonid populations. These components must then be linked to larger scale watershed processes that may control them. For example, a stream that lacks sufficient LWD often has poor LWD recruitment potential in the riparian areas of that stream. By identifying this linkage, riparian areas can be managed to include more conifers to increase LWD recruitment potential. Also, high stream temperatures can often be linked to lack of shade as a result of poorly vegetated riparian areas. By linking actual conditions to current watershed-level processes, land mangers can better understand how to manage the resources to maintain these key aquatic habitat components.

Moore et al. (1995) suggested that Tillamook Basin habitat conditions, at least for coho salmon, may be at a low point. They contended that recovery will be a slow process because key elements for recovery, such as development of conifer communities in riparian zones, are only getting started. A number of positive management actions taken over the years are likely to improve anadromous fish habitat in the watershed over the long term. Some of the most important positive actions to date are listed below.

- Reforestation of the historic burned and logged areas of the watershed began in 1949 and was completed in 1973. This management measure is acknowledged as successfully improving hydrologic response in the burned areas and has significantly reduced soil loss from these areas (OWRD and USDA-SCS 1978)

- Unregulated timber harvest in the riparian zone of fish bearing streams ended in 1972 when the 1971 Oregon Forest Practices Act took effect. Forest practice rules have been modified over the years since that time to provide greater protection to streams and their riparian zones. It is anticipated that they will continue to be modified and improved in the future.

- Tillamook Basin has been identified as a priority area for implementation of the Oregon Plan, which succeeds the Governor's Coastal Salmon Restoration Initiative, developed in 1996.

Stream Morphology

Pools are important features for salmonids, providing refugia and feeding areas. Substrate is also an important channel feature since salmonids use gravel beds for spawning. Gravel beds can be buried by heavy sedimentation, resulting in loss of spawning areas as well as reduced invertebrate habitat quality. For streams that were surveyed, stream morphology and substrate were compared with ODFW benchmarks to evaluate current habitat conditions (Table 8.5).

Table 8.5 Stream morphologic conditions in the Miami River watershed. Data were collected by ODFW (1990-1995).

Subwatershed	Stream Miles	Fish Use[1]	Miles Surveyed [2]	# Reaches Surveyed	Pool Frequency[2]	Percent Pools[2]	Residual Pool Depth[2]	Gravel[2]
Lower Miami River	12	C, FC, CH, WS, CT	4.4	2	Moderate (1)	Moderate (0)	Good (2)	Moderate (1)
Middle Miami River	28	C, FC, CH, WS, CT	19.1	9	Moderate (9)	Poor (4)	Good (4)	Moderate (4)
Moss Creek	13	C, FC, CH, WS, CT	4.2	1	Poor (1)	Poor (1)	Good (1)	Moderate (1)
Upper Miami River	37	C, FC, CH, WS, CT	25.2	5	Moderate (4)	Moderate (3)	Good (3)	Moderate (4)
Total	90		52.8	17				

[1] C=coho, FC=fall chinook, CH=chum, WS=winter steelhead, CT=cutthroat
[2] Subwatersheds were assigned categories (good, moderate, poor) based on the most prevalent category among all reaches surveyed in that subwatershed. The categories were based on how the data compared to ODFW habitat benchmarks. Number in parentheses is the number of reaches in that category.

Large Woody Debris

Large woody debris is an important feature that adds to the complexity of the stream channel. LWD in the stream provides cover, produces and maintains pool habitat, creates surface turbulence, and retains small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (Bischoff et al. 2000, BLM 1996). In-stream LWD conditions and LWD recruitment potential were generally poor to moderate in the Miami River watershed (Table 8.6).

Table 8.6 Riparian and in-stream LWD conditions in the Miami River watershed.

	Lower Miami River	Middle Miami River	Moss Creek	Upper Miami River	Total
Stream Length (mi)	12	28	13	37	90
Salmonid Use[1]	C, FC, CH, WS, CT	C, FC, CH, WS, CT	C, FC, CH, WS, CT	C, FC, CH, WS, CT	
Miles Surveyed[2]	4.4	19.1	4.2	25.2	52.8
# Reaches Surveyed	2	9	1	5	17
Riparian Recruitment	Poor	Poor	Poor	Poor	
Riparian Shade	Good	Good	Good	Good	
In-stream LWD[3]					
Pieces	Moderate (1)	Poor (6)	Poor (1)	Moderate (3)	
Volume	Poor (2)	Poor (7)	Poor (1)	Poor (4)	
Key Pieces	Good (2)	Poor (7)	Good (1)	Poor (5)	

1 C=coho, FC=fall chinook, WS=winter steelhead, CH=chum, CT=cutthroat
2 From aerial photo interpretation conducted by E&S Environmental Chemistry, Inc.
3 Subwatersheds were assigned categories (good, moderate, poor) based on the most prevalent category among all reaches surveyed in that subwatershed. The categories were based on how the data compared to ODFW habitat benchmarks. Number in parentheses is the number of reaches in that category.

Wetlands

Wetlands contribute critical functions to watershed health, such as water quality improvement, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat (Mitsch and Gosselink 1993). Because of the importance of these functions, wetlands are regulated by both State and Federal agencies. Additionally, wetlands play an important role in the life cycles of salmonids (Lebovitz 1992). Estuarine wetlands provide holding and feeding areas for salmon smolts migrating out to the ocean. These estuarine wetlands also provide an acclimation area for smolts while they are adapting to the marine environment. Riparian wetlands can reduce sediment loads by slowing down flood water, allowing sediments to fall out of the water column and accumulate. Wetlands provide cover and food in the form of a diverse aquatic invertebrate community. Backwater riparian wetlands also provide cover during high flow events, preventing juvenile salmon from being washed downstream.

Estuarine wetlands were once common in the Tillamook Bay (Boulé and Bierly 1987), although less so in the Miami River watershed than in the lower reaches of some of the other drainages. Many of the Tillamook Bay wetlands have been diked, disconnecting them from saltwater influences and changing the structure of the wetland. Existing estuarine wetlands currently accessible to salmonids should be protected or restored. Those wetlands disconnected by dikes should be evaluated for potential reconnection and restoration.

Palustrine wetlands are found in the Miami River watershed. Stream side wetlands should be protected, especially those that are in the current salmonid distribution. Streamside wetlands that have been disconnected due to diking or ditching should be evaluated for restoration opportunities. Other wetlands should be protected for their roles in maintaining water quality, flood attenuation, and habitat.

8.5 Sediment Sources

Sediment in the rivers and streams of the Miami River watershed is an issue of concern. The combination of the wet climate, steep slopes in the uplands, and very erosive soils results in naturally high levels of sediment in the river and streams. The historic wildfires in the watershed, as well as resource management practices over the past century are associated with an additional increase in sediment levels. High levels of sediment in the rivers (mainly Wilson and Trask) have been associated with increased rates of sedimentation in Tillamook Bay. Additionally, high sediment levels are associated with the declining health of salmonid populations. While naturally occurring sources of sediment in the watershed may be uncontrollable (and perhaps to some degree beneficial), the additional sediment contributed by human activity may contribute to adverse impacts on habitat quality.

In this watershed, slope instability was determined to be the most significant sediment source, although there were insufficient data regarding road instability and stream bank erosion for judging their importance. Shallow landslides and deep-seated slumps are known to be common in the Oregon Coast Range. Streamside landslides and slumps can be major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Rural roads are a common feature of this watershed, and many are present on steep slopes. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of rural roads, especially unpaved gravel and dirt roads, indicates a high potential for sediment contribution to the stream network.

Agricultural and pasture land runoff, as well as the history of fire in the Tillamook region are also contributing factors. However, agricultural and pastoral lands occupy less than 2% of this watershed, and are mostly located at the lower elevations of the watershed. Urban runoff is generally absent. Developed lands occupy less than 1% of the Miami River watershed.

Lastly, streambank erosion is a concern in the Miami River watershed. While the overall contribution of sediment from streambank erosion is probably less significant that other sources, erosion from the streambank is important in lowland areas and is also associated with a lack of riparian shade. Restoration of riparian vegetation and prevention of livestock grazing near streambanks will lessen sediment contribution from streambank erosion.

8.6 Water Quality

Water quality is controlled by the interaction of natural and human processes in the watershed. Processes that occur on the hillslope can ultimately control in-stream water quality. Pollutants are mobilized through surface and subsurface runoff and can cause degradation of stream water quality for both human use and fish habitat. Consequently, many water quality parameters are highly episodic in nature and often associated with certain land use practices. The water quality assessment is based on a process that identifies the beneficial use of water, identifies the criteria that protect these benefits, and evaluates the current water quality conditions using these criteria as a rule set (WPN 1999).

The Miami River mainstem is temperature limited from the mouth to Moss Creek. In summer months, the Miami mainstem reaches temperatures approximately 20.3ºC (68.5ºF). These data suggest that the Miami River is impaired for temperature relative to salmonid rearing and growth.

Available monitoring data suggest that nitrate concentrations have increased in the Miami River since 1979. The cause of such an increase in nitrate cannot be determined from the available data. It is possible that nitrogen fixation in large alder stands in the Miami River watershed may be contributing to higher nitrate concentration in the river. The available data suggest, however, that the Miami River water quality may be impaired with respect to nitrogen.

The Miami River is water quality limited, based on bacteria, from the mouth to Stuart Creek. Large changes in both loads and concentrations of fecal coliform bacteria are associated with storm events, especially during the fall season. Based on the available data, water quality in the Miami River appears to be impaired with respect to bacteria, as related to shellfish production and at some sites as related to water contact recreation. It has been suggested that prior moisture conditions and amount and intensity of rainfall play important roles in controlling the flux of fecal coliform bacteria into Tillamook area rivers, including the Miami (Dorsey-Kramer 1995; Jackson and Glendening 1982). Particularly high concentrations have consistently been observed during small summer storm events and the first storms after the summer low flow season.

At the screening level of this assessment, water quality in the major streams of the Miami River watershed would be considered impaired because of the frequency of exceedence of the evaluation criteria for temperature, nitrogen, and bacteria. There is no reason to suspect that the river suffers from impairment with respect to dissolved oxygen, pH, total phosphorus concentration, turbidity, or trace metals. There is not sufficient data to make a determination with respect to organic contaminants.

CHAPTER 9. RECOMMENDATIONS

General

- Prioritize restoration and watershed management activities based on information in this assessment and any other assessment work conducted in the watershed. One example is the in-stream habitat restoration guide developed by ODFW (ODFW 1997). Prioritize areas with known salmonid use for both spawning and rearing. Focus in-stream restoration work on areas with sufficient water quality for salmonids (low temperature, low turbidity) and areas with good stream channel characteristics (responsive channel habitat type, good geomorphologic conditions, good riparian shade and recruitment potential).

- Maintain relationships and contacts among the watershed council, Tillamook County Performance Partnership, Oregon Department of Forestry, the city of Garibaldi, and private timber owners to keep up-to-date on data collection, further assessment, and restoration activities in the watershed. Update assessment data sets accordingly.

- Develop an understanding of the Forest Practices Act. This will provide a better understanding of regulations and mitigation actions necessary for timber harvest.

Data

- Use a standardized base map. As a part of this assessment, a series of 1:24,000 base map layers were developed. We recommend that these layers be used as a base map and additional data be maintained at a scale of 1:24,000 or larger (i.e. 1:12,000). All of these layers will relate directly to the USGS 7.5 minute quadrangles which can be used to develop additional data layers and find locations in the field.

- Georeference all field data at a scale of 1:24,000 or better. This can be accomplished by using GPS to record latitude and longitude or by marking the location on the USGS quadrangle maps.

- Maintain data in an accessible location and format. The Tillamook County Watershed Resource Center office would be the best place for this. Most data should be maintained in a GIS format and updated annually. Some coverages will be updated periodically by the agency that created the coverage (i.e. salmonid distribution data from ODFW). These data sets should be kept current in the database.

- Collect additional data in priority areas. The decision-making framework provided with this document allows the user to select strategic locations for data collection based on features such as channel habitat type, known salmonid distribution, and water quality conditions.

- Get expert advice on data collection and processing. Consult with the Technical Advisory Committee, federal and state agencies, and consultants to develop appropriate sampling collection, quality control, and data analysis protocols.

- Evaluate the GIS data layers. Several of the data sets used to develop this assessment need to be evaluated and compared to on-the-ground conditions before restoration actions are taken or final conclusions are made about ecosystem processes. Layers that need further evaluation or updating include:

  Land Use and Wetlands
  The land use was refined from a land use coverages provided by the TBNEP, zoning, National Wetlands Inventory (NWI), and ownership. NWI data were not available digitally for the entire area and so were used only in the areas of digital coverage. As NWI data become more readily available in digital format, the land use coverage should be updated. All land use categories should be field verified before restoration actions occur.

  Roads
  The roads coverage is a key coverage used to evaluate potential sediment sources and changes in watershed hydrology associated with road construction. However, the roads coverage may not accurately represent on-the-ground conditions in this watershed.

  Channel Habitat Types
  Channel habitat types were determined using GIS. Limited field verification of these data suggest that the data accurately represent actual on-the-ground conditions (through visual comparison). However, the channel habitat type should be further verified in the field before any restoration actions occur.

  Riparian Vegetation and Shade
  Riparian conditions need to be further evaluated before restoration actions occur. A visual comparison of field checks to the aerial photo interpretations found the data to be fairly consistent. After site selection using the GIS data, the stream reach identified should be field checked for actual on-the-ground conditions.

- Refine the land use layer. Continue to develop the land use layer to reflect changes in land use. Update the layer with digital NWI data as they become available.

Fisheries

- Develop and update a fish limits coverage, in cooperation with on-going activities by ODF.

- Efforts to inventory anadromous salmonid habitat throughout the watershed should continue.

- Work with ODFW to identify viable populations and distributions of sensitive species, particularly salmonids. These data are critical in developing watershed enhancement strategies.

- Identify and survey areas currently used by salmonids. Collect stream survey data according to ODFW protocols. These data will help identify habitat limitations and areas that may provide good habitat but are currently blocked by a barrier.

Aquatic Habitats

- Field verify the channel habitat type GIS data layer. Some data have already been collected and visually compared to the layers.

- Field verify the riparian GIS data layers. Some data have already been collected and visually compared to the layers.

- Areas of good habitat should be identified and protected. This should include an analysis of the watershed upstream from the good habitat to locate potential problems that could result in future degradation to the habitat.

- Where feasible, habitat should be improved through the creation of off-channel winter habitat and introduction of LWD. Efforts should focus first on locations where the target fish species are known to be present.

- Long-term monitoring in the watershed is needed to evaluate changes in habitat and system productivity for juvenile salmonids through time. One approach might be to select representative reaches in upper, mid, and lower sections of the major subwatersheds as monitoring sites. Parameters to monitor would need to be carefully selected to provide the most information with the least expenditure of time and money (TBNEP 1998).

- In the estuary, information is needed on the relative importance of major habitat types to the various anadromous salmonid species. This could be accomplished through focused sampling of specific habitat types when the various salmonid species are present (TBNEP 1998).

- Integrated long-term monitoring should be designed to provide the input needed to test hypotheses regarding the effects of changes in estuarine conditions on juvenile salmonid rearing habitat in the estuary (TBNEP 1998).

- Development of quantitative or semi-quantitative measures of estuarine habitat quality — similar to those used in the freshwater environment to classify stream habitat — would help us monitor long-term trends in habitat quality (TBNEP 1998).

- Eelgrass bed monitoring should continue, due to the importance of eelgrass as fish and wildlife habitat (TBNEP 1998).

- Prioritize stream reaches for restoration of riparian vegetation. Start in areas currently used by salmonids and lacking in LWD recruitment potential, good shade conditions, or in-stream LWD.

- Restore deep water pools.

- Plant riparian conifers and native species in areas lacking LWD recruitment potential. Start in areas of known salmonid use, and use the riparian vegetation map provided with this assessment and ODFW stream surveys to identify candidate reaches. Before any reaches are targeted for planting, they should be field verified for suitability and actual conditions. Vegetation planting should use only native species and mimic comparable undisturbed sites.

- Develop a riparian fencing strategy to maintain riparian vegetation.

- Develop a GIS database for the results of culvert surveys for fish passage.

- Complete a culvert survey of all culverts that have not been evaluated for fish passage. Data should be maintained in a GIS. The road/stream crossing coverage is a good place to start. The culvert survey should begin in priority subwatersheds at the mouth of each of the streams. Establish priorities for culvert replacement.

- Replace priority culverts identified in the culvert survey.

- Install fish passages at known fish passage barriers that are caused by human influences.

- Prioritize estuarine wetlands for restoration, creation, or maintenance based on their value to salmonids. Landowners with priority wetlands can then be contacted for possible wetland restoration.

- Prioritize for restoration, creation, or maintenance, palustrine wetlands that are connected to streams and provide back water rearing areas for salmonids. Start in areas with known salmonid rearing and spawning habitat.

- Create, restore, and maintain palustrine wetlands based on their prioritization.

- Identify and protect high-quality floodplain vegetative communities.

- Restore floodplain vegetation in priority lowland restoration areas.

- Perform a feasibility study to identify opportunities for floodplain restoration. Evaluate findings from the TBNEP demonstration grant project assessing the feasibility of restoring estuarine wetlands by breaching dikes. Explore opportunities for floodplain restoration for flood hazard reduction in non-tidal portions of the river valleys (TBNEP 1998).

- Educate the public about the historic function of the rivers and their floodplains. Most people are not aware of the "way things were" before settlement in the Tillamook Bay river valleys. If the public understood the reasons why the floodplains are so fertile and how floods used to shape the landscape, floodplain management measures, such as relocation and restoration, might become more acceptable (TBNEP 1998).

Hydrology and Water Use

- Update and refine the roads layer. Keep in contact with ODF and other groups (private land owners) as the roads layer is updated to evaluate its accuracy.

- Develop an outreach program to encourage water conservation. Educate the public about dewatering effects and how water conservation will help salmonids in the watersheds.

- Identify water rights that are not currently in use and that may be available for in-stream water rights through leasing or conversion.

Sediment

- Identify roads that have not been surveyed for current conditions and fill these data gaps. Work with ODF to develop road survey methodologies.

- Map road failures in areas where data are lacking. Coordinate with watershed stakeholders that are currently collecting road data such as ODF and private timber companies. Develop a strategy to fill in the data gaps.

- Map culvert locations and conditions in conjunction with the culvert survey conducted for fish passage barriers. Check with ODF, ODFW, and local foresters for the best methodologies and data to collect.

- Map all debris flows and landslides. Begin in the areas most susceptible to landslide activity.

- Where possible, conduct road restoration activities such as road reconstruction, decommissioning, and obliteration.

- Replace undersized culverts that are at risk of washing out. Prioritize these culverts from the culvert surveys.

- Monitor sediment recruitment, for example using gravel traps.

Water Quality

- Reinstate water quality monitoring efforts at Moss Creek Bridge for fecal coliform bacteria, total suspended solids, and nutrients.

- Develop a systematic water quality monitoring program for areas with high priority for restoration activity. Focus the water quality monitoring on constituents that are important for the specific area being restored. Use the water quality data to refine the restoration plans.

- Develop or expand the continuous temperature monitoring network with monitors at strategically located points such as the mouths of tributary streams, locations of known spawning beds, at the interface between major land use types, or downstream of activities with the potential to influence water temperature.

- Include a plan for long-term monitoring in any restoration plan to measure the effects of the restoration activity.

- Begin to develop the capacity within the watershed council to conduct high quality, long term water quality monitoring to document the success of restoration activities.

- Locate and map potential sources of nitrogen, phosphorus, and bacteria in the watershed.

- Conduct all water quality monitoring activities according to established guidelines such as those published by the Oregon Plan for Salmon and Watersheds (OPSW 1999), or EPA (1997, 1993).

- Cooperate with DEQ and other agencies to share data and expertise. Coordinate the council's monitoring activities with those of the agencies, including DEQ's efforts to develop Total Maximum Daily Loads (TMDLs) for water quality limited stream segments.

CHAPTER 10. REFERENCES

Allen, K. 1969. Limitations on production in salmonid populations in streams. In: T. Northcote, ed., Symposium on salmon and trout in streams. University of British Columbia, Vancouver, Canada, pp. 3–18.

Amaranthus, M., R. Rice, N. Barr, and R. Ziemer. 1985. Logging and forest roads related to increased debris slides in Southwestern Oregon. Journal of Forestry 83: 229–233.

Arnold, J.G., J.R. Williams, A.D. Nicks, and N.B. Sammons. 1989. SWRRB, A basin scale simulation model for soil and water resources management. Texas A&M Press, College Station, TX.

Bastasch, R. 1998. Waters of Oregon. A Source Book on Oregon's Water and Water Management. Oregon State University Press, Corvallis, OR

Beechie, T., E. Beamer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14:797-811.

Benoit, C. 1978. Hydrologic analysis for forested lands Tillamook Basin. USDA Forest Service, Pacific Northwest Region.

Beschta, R. L. 1997. Riparian shade and stream temperature: an alternative perspective. Rangelands. 19:25-28.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperatures and aquatic habitat: Fisheries and forestry interactions. p. 191-232 In: Streamside management: Forestry and fisheries interactions. Contribution No. 57, Institute of Forest Resources. University of Washington, Seattle.

Binkley, D. and T.C. Brown. 1993. Forest Practices as Nonpoint Sources of Pollution in North America. Water Resources Bulletin 29(5):720-729.

Bischoff, J.M., R B. Raymond, K.U. Snyder, L. Heigh, and S.K. Binder. 2000. Youngs Bay Watershed Assessment. E&S Environmental Chemistry, Inc. and Youngs Bay Watershed Council. Corvallis, OR.

Blair, T. and K. Michener. 1962. Sanitary survey of Tillamook Bay and sanitary significance of the fecal coliform organism in shellfish growing area waters. Internal report, Oregon State Board of Health, Portland, OR.

Bodenmiller, D. 1995. Section 5, Harvest Management. As cited in: Tillamook Bay Coho Task Force, ed., Tillamook Bay coho stock status report, Oregon Department of Fish and Wildlife.

Botkin, D. B., K. Cummins, T. Dunne, H. Regier, M. Sobel, L. Talbot, and L. Simpson. 1995. Status and future of Salmon of Western Oregon and Northern California. Research Report 951002, The Center for the Study of the Environment. Santa Barbara, California.

Bottom, D.L., J.A. Lichatowich, and C.A. Frissell. 1998. Variability of Pacific Northwest Marine Ecosystems and Relation to Salmon Production. In McMurray, G.R. and R.J. Bailey (eds.). Change in Pacific Northwest Coastal Ecosystems. NOAA Coastal Ocean Program, Decision Analysis Series No. 11, Silver Spring, MD. pp. 181-252.

Boulé, M.E. and K.F. Bierly. 1987. The history of estuarine development and alteration: what have we wrought? Northwest Environmental Journal 3(1):43-61.

Boyd, M and D. Sturdevant. 1997. The scientific basis for Oregon's stream temperature standard: common questions and straight answers. Oregon Department of Environmental Quality. Portland, OR.

Bureau of Land Management (BLM). 1996. Thomas Creek Watershed Analysis. U.S. Department of the Interior, Bureau of Land Management, Salem District Office, Salem, OR.

Busby, P., T. Wainwerght, G. Bryant, L. Lierheimer, R. Waples, F. Waknitz, and I. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS–NWFSC–27. 195 pp. + appendices.

Canale, G. 1999. Oregon Coast Range Macroinvertebrate Analysis and Monitoring Status. Tech. Rept. BIO99-005. Oregon Dept. of Environmental Quality, Portland, OR.

Center for Population Research and Census. 1997. General Population Statistics. Portland State University, Portland, OR.

Chesney, C. 1982 "Mass erosion occurence and debris torrent impacts on some streams in the Willamette National Forest." Master's thesis, Oregon State University. Corvallis, OR.

Chilcote, M., and M. Lewis. 1995. Section 6, Use of hatchery coho in the Tillamook System. As cited in: Tillamook Bay Coho Task Force, ed., Tillamook Bay coho. Stock status report Oregon Department of Fish and Wildlife.

Cleary, P. 1996. Memorandum from Paul Cleary, dir., Oregon Division of State Lands to Coast Wide Ready Mix, et al. Subject: Signatories to the 1992 Tillamook County gravel mediated agreement, Nov. 13.

Collins, B., and T. Dunne. 1990. Fluvial geomorphology and river gravel mining: A guide for planners, case studies included. California Department of Conservation, Division of Mines and Geology, 1416 9th Street, Room 1341, Sacramento, CA. 95814.

Conroy, S.C. 1997. Habitat lost and found. Washington Trout Report. Vol. 7:1.

Cooke, R., and J. Doornkampe. 1978. Geomorphology in environmental management: An introduction. Clarendon Press, Oxford, England. 413 pp.

Coulton, K., P. Williams, and P. Brenner. 1996. An Environmental History of the Tillamook Bay Estuary and Watershed. Report to the TBNEP, Garibaldi, OR.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-79/31.

Daly, C., R.P. Neilson, and D.L. Phillips. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. Journal of Applied Meteorology, 33, 140-158.

Dorsey-Kramer, J. 1995. A statistical evaluation of the water quality impacts of Best Management Practices installed at Tillamook County dairies. Thesis submitted to Oregon State University, Corvallis, OR.

Earth Design Consultants. 2000. Mid Coast Watershed Assessment. Mid Coast Watershed Council.

Emmett, R.L., S.A. Hinton, S.L. Stone 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.

Flemming, I.A. and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecol. Applic. 3:230-245.

Flemming, I.A. and M.R. Gross. 1989. Evolution of adult female life history and morphology in a Pacific salmon (coho: *Oncorhynchus kisutch*). Evolution 43:141-157.

Franklin, J. and C. Dyrness. 1973. Natural Vegetation of Oregon and Washington, USDA Forest Service, Portland, OR.

Frenkel, R.E. and J.E. Morlan. 1991. Can we restore our salt marshes? Lessons from the Salmon River, Oregon. Northwest Environmental Journal 7:119-135.

Garibaldi, City of. 1993. Garibaldi Master Water Plan, Garibaldi, Oregon.

Garono, R. and L. Brophy. 1999. Rock Creek (Siletz) Watershed Assessment Final Report. Earth Design Consultants, Inc., Corvallis, OR.

Glenn, J. 1978. "Sediment sources and Holocene sedimentation history in Tillamook Bay, Oregon: Data and preliminary interpretations." Prepared by U.S. Geological Survey in cooperation with the Soil Conservation Service. Open file report 78-680.

Hargreaves, N.B. and R.J. LeBrasseur. 1986. Size selectivity of coho (*Oncorhynchus kisutch*) preying on juvenile chum salmon (*O. keta*). Can. J. Fish. Aquat. Sci. 43:581-586.

Harr, R.D. 1983. Potential for augmenting water yield through forest practices in western Washington and western Oregon. Water Resour. Bull. 19:383-393.

Harr, R.D., W.C. Harper, J.T. Krygier, and F.S. Hsieh. 1975. Changes in storm hydrographs after road building and clear-cutting in the Oregon Coast Range. Water Resour. Res. 11:436-444.

Hasselman, R. 1995. Section 1, executive summary. As cited in: Tillamook Bay Coho Task Force, ed., Tillamook Bay coho stock status report. Oregon Department of Fish and Wildlife.

Hatch, K.M. 1990. A phenotypic comparison of thirty-eight steelhead (*Oncorhynchus mykiss*) populations from coastal Oregon. M.S. Thesis. Oregon State University, Corvallis.

Healey, M.C. 1982. Juvenile pacific salmon in estuaries: The life support system. In: Kennedy, V. (ed.). Estuarine Comparisons. New York, NY. pp. 315-341.

Healey, M.C. 1994. Variation in the life history characteristics of chinook salmon and its relevance to conservation of the Sacramento winter run of chinook salmon. Cons.Biol. 8:876-877.

Hemmingsen, A.R., R.A. Holt, and R.D. Ewing. 1986. Susceptibility of progeny from crosses among three stocks of coho salmon to infection by *Ceratomyxa shasta*. Transactions of the American Fish. Soc. 115:492-495.

Hinzman, R. and S. Nelson, eds.. 1998. Tillamook Bay Environmental Characterization. A Scientific and Technical Summary. Tillamook Bay National Estuary Project.

Hjort, R.C. and C.B. Schreck. 1982. Phenotpyic differences among stocks of hatchery and wild coho salmon, *Oncorhynchus kisutch*, iin Oregon, Washington, and California. Fish. Bull. 80:105-119.

Iwamoto, R., and E. Salo. 1977. Estuarine survival of juvenile salmonids: A review of the literature. Report to Washington Department of Fisheries, Fisheries Research Institute., University of Washington, Seattle, WA

Jackson, J. and E. Glendening. 1982. Tillamook Bay bacteria study fecal source summary report. Oregon Department of Environmental Quality, Portland, OR.

Johnson, R. R. and J.F. McCormick. 1979. Strategies for protection and management of floodplain wetlands and other riparian ecosystems. Gen. Tech. Report WO-12. U.S. Forest Service, Washington, DC.

Kauffman, J. B., R. L. Beschta, N. Ottig, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the Western United States. Fisheries 22:12-23.

Komar, P. 1997. Sediment accumulation in Tillamook Bay, Oregon, a large drowned-river estuary. Tillamook Bay National Estuary Project, Garibaldi, OR.

Kondolf, G., and M. Wolman. 1993. The sizes of salmonid spawning gravels. Water Resources Research (in press).

Kostow, K. 1996. The status of salmon and steelhead in Oregon. As cited in: D. J. Strouder, P. A. Bisson, and R. J. Naiman, ed., Pacific salmon and their ecosystems, status and future options, Chapman and Hall, NY. 685 pp.

LaFrance, D. and B. McDonald. 1995. Current state and federal forest management practices that affect sediment delivery. In: Tillamook Bay National Estuary Project, Scientific/Technical Advisory Committee Issue Form on Impact of Erosion and Sedimentation in Tillamook Bay and its Watershed, January 12.

Lebovitz, M.E.S. 1992. Oregon estuarine conservation and restoration priority evaluation. Opportunities for salmonid habitat and wetlands functions enhancement in Oregon's estuaries. Report prepared for Oregon Trout and U.S. Fish and Wildlife Service. Yale Univ., New Haven, CT.

Leopold, L., M. Wolman, and J. Miller. 1992. Fluvial processes in geomorphology. Dover Publications, Inc., New York, NY.

Levesque, P. 1985. A chronicle of the Tillamook County Forest Trust Lands. Vol. 1. Published for Tillamook County, Tillamook, OR.

Light, T. 1987. Coastwide abundance of North American steelhead trout. (Document submitted to the annual meeting of the International North Pacific Fisheries Conference, 1987) Fisheries Research Institute report FRI–UW–8710. University of Washington, Seattle, WA. 18 pp.

MacDonald, J.S., C.D. Levings, C.D. McAllister, U.H.M. Fagerlund, and J.R. McBride. 1988. A field experiment to test the importance of estuaries for chinook salmon (*Oncorhychus tshawytscha*) survival: Short-term results. Canadian Journal of Fisheries and Aquatic Sciences 45:1366-1377.

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin, and J. Van Sickle. 1990. Source distances for coase woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research 20:326-330.

Miller, J. and R.Garono. 1995. Issue forum summaries. Prepared for the Tillamook Bay National Estuary Project, Tillamook, OR.

Mills, K. 1997. Landslides and their association to forest practices for the storm. Proceedings of the Pacific Northwest Water Issues Conference. American Institute of Hydrology. Portland, OR. 318 pp.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands. 2nd ed. Van Nostrand Reinhold, New York.

Moore, K., K. Jones, and J. Dambacher. 1997. Methods for stream habitat surveys. Aquatic inventory Project. Oregon Department of Fish and Wildlife, Natural Production Program, Corvallis, OR. 45 pp.

Musselman, J. 1986. Sanitary survey of shellfish waters. Tillamook Bay, Oregon, Dec. 1986. U.S. Dept. of Health and Human Services, Public Health Service, Food and Drug Administration, Shellfish Sanitation Branch.

Naiman, R.J. and R.E. Bilby, editors. 1998. River Ecology and Management. Lessons from the Pacific Coastal Ecoregion. Springer, New York.

National Research Council. 1996. "Landslides investigation and mitigation." Special report 247. Transportation Research Board, National Research Council. Washington, DC.

Nicholas, J.W. and D.G. Hankin. 1989. Chinook salmon populations in Oregon coastal river basins: description of life histories and assessment of recent trends in run strengths. 2nd ed. Oregon Dept. of Fish and Wildlife, Corvallis, OR.

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 informational report no. 88–1. 359 pp.

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 Department of Fish and Wildlife. Corvallis, OR.

Nickelson, T.E., M.F. Solazzi, and S.L. Johnson. 1986. Use of hatchery coho salmon (*Oncorhynchus kisutch*) presmolts to rebuild wild Nicholas and Hankin 1988

Oregon Department of Environmental Quality. 2000. Web Page. http://waterquality.deq.state. or.us/SISData/

Oregon Department of Environmental Quality. 1999. Final 1998 Water Quality Limited streams- 303(d) list. http://waterquality.deq.state. or.us/303dlist/303dpage.htm. Accessed 8/13/00.

Oregon Department of Fish and Wildlife. 2000. Web page. *ftp://ftp.dfw.state.or.us/pub/gis*.

Oregon Department of Fish and Wildlife. 1997. Summary of January 6, 1997 ODFW Comments to National Marine Fisheries Service Concerning the Listing of Steelhead under the Endangered Species Act. ODFW, Portland, OR.

Oregon Department of Fish and Wildlife. 1995. Biennial Report on the Status of Wild fish in Oregon. Oregon Dept. of Fish and Wildlife, Portland, OR.

Oregon Department of Fish and Wildlife. 1994. Tillamook/North Coast Salmonid Habitat Restoration: Guide to Project Selection.

Oregon Department of Forestry. 1999. Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report. Oregon Dept. of Forestry, Salem, OR.

Oregon Natural Resources Council (ONRC) and others. 1994. Petition for a rule to list steelhead trout as threatened or endangered under the Endangered Species Act and to designate critical habitat. Unpublished manuscript (document submitted to the USDOC NOAA NMFS Northwest Region, Seattle, WA., February 1994). 133 pp.

Pedone, P. 1995. Delivery of sediments to Tillamook Bay in the past: A summary of the 1978 Tillamook Bay drainage basin erosion and sedimentation study. Impacts of erosion and sedimentation in Tillamook Bay and Watershed. Summary of a TBNEP Scientific/Technical Advisory Committee forum. Tillamook Bay National Estuary Project, Garibaldi, OR.

Pyles, M., and H. Froehlich. 1987. Discussion and reply. Rates of landsliding as impacted by timber management activities in northwestern California. Bulletin of the Association of Engineering Geologists. Vol. 24, No. 3. pp. 425–431.

Reisenbichler, R.R. 1988. Relation between distance transferred from natal stream and recovery rate for hatchery coho salmon. N. Amer. J. Fish. Mgmt. 8:172-174.

Reisenbichler, R. R., and S. R. Phelps. 1989. Genetic variation in steelhead (Salmo gairdneri) from the north coast of Washington. Can. J. Fish. Aquat. Sci. 46:66-73.

Reisenbichler, R. R., J. D. McIntyre, M. F. Solazzi, and S. W. Landino. 1992. Genetic variation in steelhead of Oregon and northern California. Trans. Am. Fish. Soc. 121:158-169.

Robison, E.G. 1991. Methods for Determining Streamflows and Water Availability in Oregon. Hydrology Report #2. Oregon Water Resources Dept.

Rothacher, J. 1973. Does harvest in west slope Douglas-fir increase peak flow in small streams? Res. Paper PNW-163. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 13 p.

Rothacher, J. 1971. Regimes of streamflow and their modification by logging. In: Krygier, J.T. and J.D. Hall, eds. Proceedings of the symposium on forest land use and stream environment; Oregon State University, Corvallis, OR. pp. 55-63.

Ryman, N., and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conserv. Biol. 5:325-329.

Sessions, J., J.C. Balcom, and K. Boston. 1987. Road location and construction practices: effects on landslide frequency and size in the Oregon Coast Range. Western Journal of Applied Forestry 2(4):119-124.

Sheppard, D. 1972. The present status of the steelhead trout stocks along the Pacific Coast. As cited in: D. H. Rosenberg, ed., A review of the oceanography and renewable resources of the northern Gulf of Alaska. IMS Report R72-23, Sea Grant report 73–3. Institute of Marine Science, University of Alaska, Fairbanks, AK.

Shields, F. and C. Cooper. 1994. Riparian wetlands and flood stages. Proceedings of the conference Hydraulic Engineering '94 Volume 1, G. Cotroneo and R. Rumer, eds, American Society of Civil Engineers, Buffalo, NY, August 1–5, pp. 351–355.

Shreffler, D.K., C.A. Simenstad, and R.M. Thom. 1992. Foraging by juvenile salmon in a restored estuarine wetland. Estuaries 15(2):204-213.

Sidle, R., A. Pearce, and C. O'Loughlin. 1985. "Hillslope stability and land use." American Geophysical Union, Water resources monograph 11. Washington, D.C.

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. As cited in: B. R. Miteff and R. A. Nevè, ed., Proc. North Pacific Aquaculture Symposium Report 82–2. Alaska Sea Grant Program, University of Alaska, Fairbanks, AK.

Simenstad, C., D. Jay, C. McIntire, W. Nehlsen, C. Sherwood, and L. Small. 1984. The dynamics of the Columbia River estuarine ecosystem Volume II. Columbia River Estuary Data Development Program.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function. In: Kennedy, V. (ed.). Estuarine Comparisons. New York, NY. pp. 343-364.

Soil and Water. 1985. Attacks on the Otaki: Gravel or grants? Anonymous article in Soil & Water magazine, National Water and Soil Conservation Authority, Wellington, New Zealand. 21(2): 2–6.State of Oregon Department of Geology and Mineral Industries. 1973. Environmental geology of inland Tillamook and Clatsop Counties, Oregon, Bulletin 79, July.

State Soil and Water Conservation Commission. 1972. "Streambank erosion in Oregon." A report to the 57th Legislative Assembly.

Sulllivan, T.J., J.M. Bischoff, K.U. Snyder, R.B. Raymond, S. White, and S.K. Binder. 2001. Wilson River Watershed Assessment. E&S Environmental Chemistry, Inc., Corvallis, OR.

Sulllivan, T.J., J.M. Bischoff, K.B. Vaché, M. Wustenberg, and J. Moore. 1998a. Water Quality Monitoring in the Tillamook Watershed. E&S Environmental Chemistry, Inc., Corvallis, OR

Sullivan, T.J., J.M. Bischoff, and K. Vaché. 1998b. Results of storm sampling in the Tillamook Bay Watershed. E&S Environmental Chemistry, Inc., Corvallis, OR.

Taylor, G.H. and R.R. Hatton. 1999. The Oregon Weather Book - A State of Extremes. Oregon State Univ. Press, Corvallis. 242 pp.

TBNEP. 1999. Tillamook Bay Conprehensive Conservation and Management Plan.

Tillamook Bay National Estuary Project. 1995. Public attitude questionnaire, Garibaldi, OR.

Tillamook Bay National Estuary Project. 1998. Tillamook Bay Environmental Characterization. A Scientific and Technical Summary. Final report prepared under Cooperative Agreement #CE990292–1 with the U.S. Environmental Protection Agency. Garibaldi, OR.

Tillamook County Soil & Water Conservation District. 1996. Moss Creek Rehabilitation Project. Governor's Watershed Enhancement Board (GWEB) Project #88-041B. 1996 Monitoring Report.

Tuchmann, E., K.P. Cannaughton, L.E. Freedman, and C.B. Moriwaki. 1996. The Northwest Forest Plan: A Report to the President and Congress. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 253 pp.

U.S. Department of Agriculture. 1978. Tillamook Bay drainage basin erosion and sediment study. Cooperative study by The Tillamook Bay Task Force, Oregon State Water Resources Department, USDA Soil Conservation Service Forest Service-Economics, Statistics and Cooperative Service.

U.S. Department of Agriculture. 1964. Soil Survey, Tillamook County. Series 1957. No. 18.

U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1990. North American Waterfowl Management Plan: Pacific Coast Joint Venture; Pacific coast habitat: a prospectus. USFWS, Portland, OR.

U.S. Department of Health and Human Services, Public Health Service, Food and Drug Admin. 1995. National Shellfish Sanitation Program manual of operations. Part I, Sanitation of shellfish growing waters. Center for Food Safety and Applied Nutrition, Office of Seafood, Program and Enforcement Branch, Washington, DC.

United States Bureau of Census. 1990. General social and economic characteristics.

Watershed Professionals Network. 1999. Oregon Watershed Assessment Manual. June 1999. Prepared for the Governor's Watershed Enhancement Board, Salem, OR.

Whelan, R. 1995. An economic analysis of construction aggregate markets and the results of a long-term forecasting model for Oregon. State of Oregon Department of Geology and Mineral Industries special paper 27.

Wiltsey, M. 1990. Tillamook Bay watershed bacterial trends assessment. Dept. of Environmental Quality. Internal repo.rt., Portland, OR.

Wissmar, R. 1986. Carbon, nitrogen and phosphorus cycling in Pacific Northwest estuaries. As cited in: Wetland functions, rehabilitation, and creation in the Pacific Northwest: The state of our understanding: Proceedings of a conference. Olympia, WA.

Wissmar, R., and C. Simenstad. 1984. Surface foam chemistry and productivity in the Duckabush River Estuary, Puget Sound, Washington. As cited in: V.S. Kennedy, ed., The estuary as a filter. Academic Press, Inc., New York, NY.