U.S. Department of the Interior
Bureau of Land Management

Salem District Office
Tillamook Resource Area
4610 Third Street
Tillamook, Oregon 97141

March 1999

Dairy-McKay Watershed Analysis

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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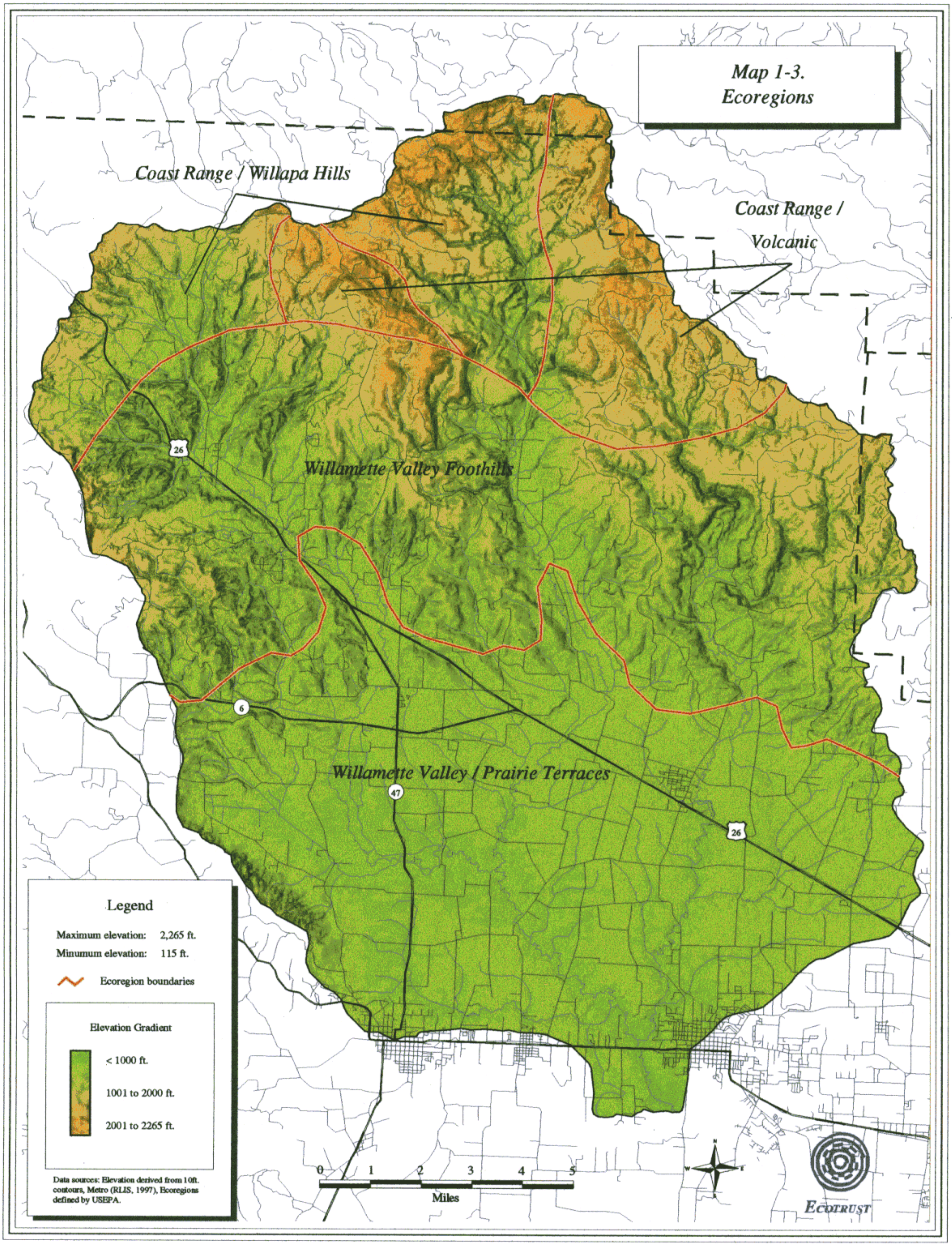

Map 1-3.
Ecoregions
Coast Range / Willapa Hills
Coast Range / Volcanic
Willamette Valley Foothills
Willamette Valley / Prairie Terraces
26
6
47
26
Legend
Maximum elevation: 2,265 ft.
Minumum elevation: 115 ft.
Ecoregion boundaries
Elevation Gradient
< 1000 ft.
1001 to 2000 ft.
2001 to 2265 ft.
Data sources: Elevation derived from 10ft. contours, Metro (RLIS, 1997), Ecoregions defined by USEPA.
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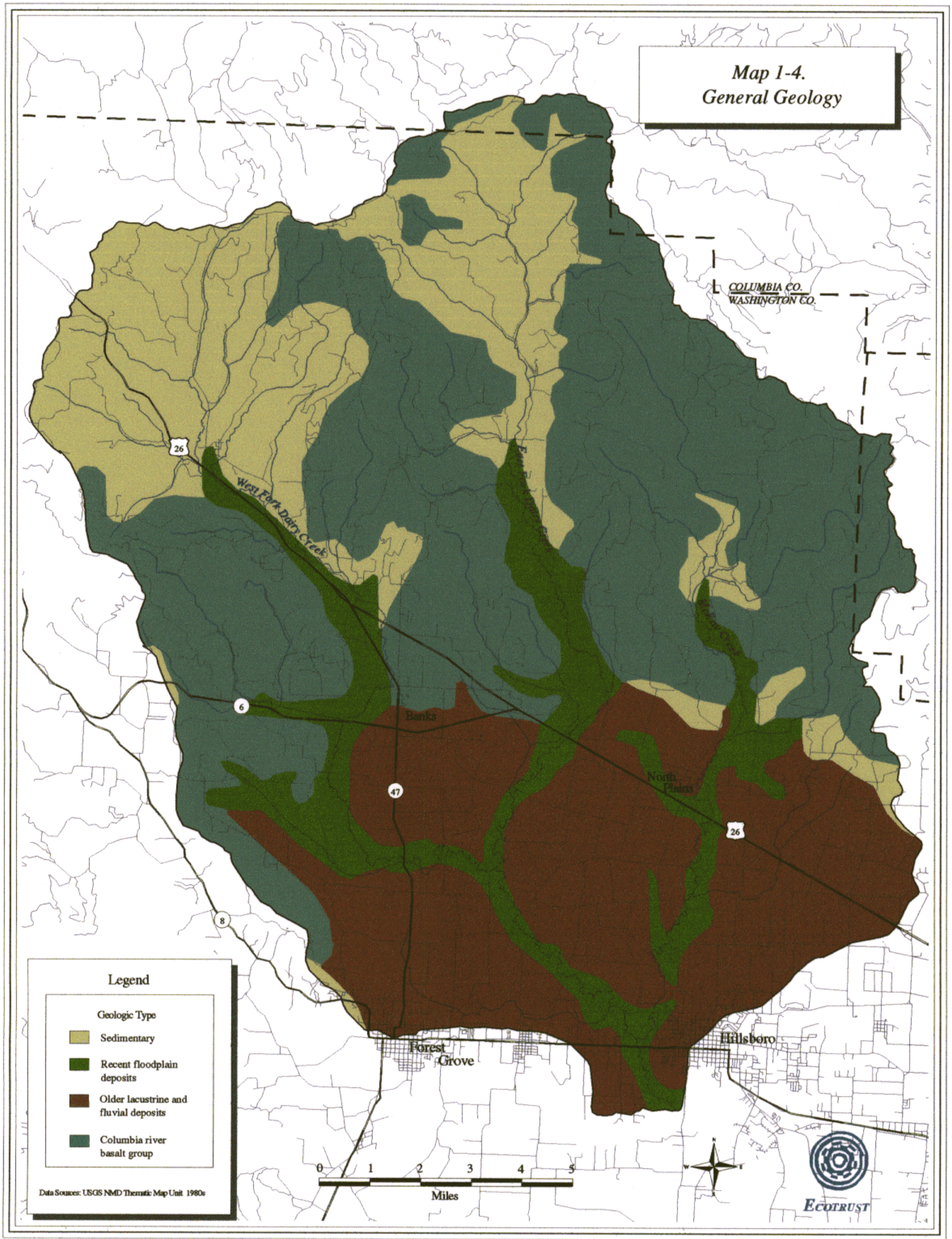


Map 1-4.
General Geology
COLUMBIA CO.
WASHINGTON CO.
West Fork Dairy Creek
26
6
47
8
Banks
North Plains
Forest Grove
Hillsboro
Legend
Geologic Type
Sedimentary
Recent floodplain deposits
Older lacustrine and fluvial deposits
Columbia river basalt group
Data Sources: USGS NMD Thematic Map Unit 1980s
0 1 2 3 4 5
Miles
ECOTRUST

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Tillamook Resource Area Office
P. O. Box 404
4610 Third Street
Tillamook, OR 97141

IN REPLY REFER TO:

7300

May 26, 1999

Attached is a copy of the Dairy-McKay Watershed Analysis prepared through a partnership between Washington County Soil and Water Conservation District and the Bureau of Land Management. The following acknowledgments page demonstrates the breadth of cooperation and valuable assistance received during this effort.

This watershed analysis is a combination of current inventory data provided by a BLM interdisciplinary team and information gathered by the principal author John Hawksworth, of Washington County SWCD. The purpose of this watershed analysis is to provide reference information that is used in project planning. The information in this document is the most current data available.

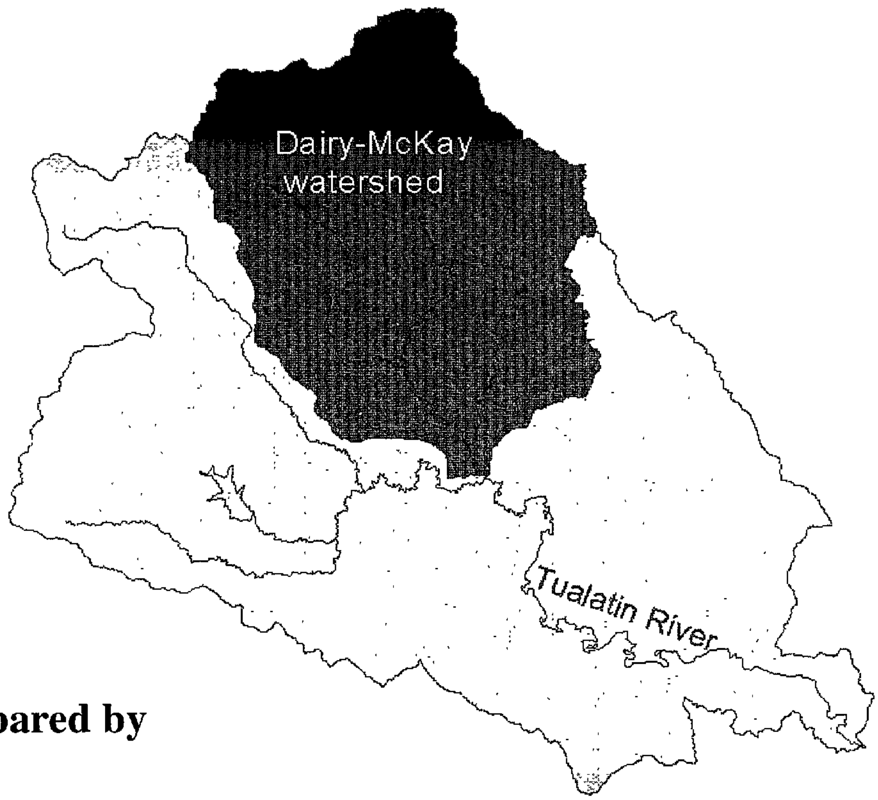
Watershed analysis is a continuing process. This document represents the first iteration of the analysis which will be updated in the future as additional information is obtained. Additional information and comments are encouraged and will be welcomed at any time on this watershed analysis. The information will be retained with the analysis, used accordingly and eventually evaluated and incorporated into future iterations.

If you have any questions, please contact Katrina Symons at the above address or phone 503-815-1100.

Sincerely,

Dana R. Shuford Date: 5-26-99
Dana R. Shuford, Field Manager
Tillamook Resource Area

DAIRY-MCKAY WATERSHED ANALYSIS



Prepared by

John Hawksworth, principal author
Washington County Soil and Water Conservation District

In cooperation with
United States Bureau of Land Management
United States Fish and Wildlife Service

February 1999

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Abbreviations and Acronyms

BA	Bureau Assessment
BLM	Bureau of Land Management
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BS	Bureau Sensitive
CD	Compact Disk
CERCLA	Comprehensive Environmental Response Compensation and Liability act of 1980
cfs	cubic feet per second
DBH	Diameter at Breast Height
D.O.	Dissolved Oxygen
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FEMAT	Federal Ecosystem Management Assessment Team
FSA	Farm Service Agency
FT	Federal Threatened (under the ESA)
GFMA	General Forest Management Area
GIS	Geographic Information System
gpm	gallons per minute
GWEB	Governor's Watershed Enhancement Board
IBI	Index of Biotic Integrity
LSR	Late Successional Reserve
LSRA	Late Successional Reserve Assessment
LWD	Large Woody Debris
Metro	Metropolitan Service District
NFP	Northwest Forest Plan
NRCS	Natural Resources Conservation Service
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Division of State Lands
OED	Oregon Employment Department
OGI	Oregon Graduate Institute
OSU	Oregon State University
OWRD	Oregon Water Resources Department
O&C	Oregon and California Railroad
RM	River Mile
RMP	Resource Management Plan
ROD	Record of Decision
ROS	Rain on Snow
SB1010	Senate Bill 1010 (Agricultural Water Quality Mgmt. Area Plan)
SWCD	Soil and Water Conservation District (Washington County)
S&M	Survey and Manage
SV	Sensitive Vulnerable species designation (State of Oregon)
TAC	Technical Assistance Committee
TCOD	Total Chemical Oxygen Demand
TMDL	Total Maximum Daily Load
TRWC	Tualatin River Watershed Council
TVID	Tualatin Valley Irrigation District
UGB	Urban Growth Boundary
USA	Unified Sewerage Agency of Washington County
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WPA	Works Progress Administration
WQI	Water Quality Index

Introduction

The concept of watershed analysis is built on the premise that management and planning efforts are best addressed from the watershed perspective. Better decisions are made, and better actions taken, when watershed processes and other management activities within a watershed are taken into consideration. Issues related to erosion, hydrologic change, water quality, and species are not limited to a specific site. Changes to watershed processes at one site often have effects that extend downstream and elsewhere in the watershed. By addressing these issues at the watershed level, we take the interconnected nature of watershed processes into account. We are thereby enabled to synthesize approaches to planning and management that preserve ecosystem functions. Where these functions have been diminished from reference conditions, we are able to plan activities to restore these functions.

In keeping with the principle of ecosystem analysis at the watershed scale, the Bureau of Land Management (BLM) has formed a partnership agreement with the Washington County Soil and Water Conservation District (SWCD) to prepare the Dairy-McKay Creek Watershed Analysis. The United States Fish and Wildlife Service (USFWS) also participated in production of this watershed analysis. The missions of these agencies are complementary. The BLM manages lands that are mostly in mountainous, forested portions of the watershed. The BLM is charged with several management duties by the people of the United States. As part of its stewardship role, the BLM is mandated to maintain ecosystem functions and processes. This includes maintenance of wildlife habitat. The USFWS has the mandate to protect terrestrial wildlife, aquatic species, and their habitat. As part of its mission, the SWCD works with farmers to conserve the soil resources of the valley, and to protect water quality within the watershed. The Washington County SWCD is mostly active within lower portions of the watershed. Together these agencies cover many of the interests within the watershed. This watershed analysis report is designed to address questions of interest to these agencies. However, in recognition that diverse interests exist in the watershed that are not covered by these agencies, this watershed analysis is also designed to be consistent with the interests of the Tualatin River Watershed Council, as expressed by the Tualatin River Basin Action Plan. Within the time and financial limitations of this report, it has done so.

The framework of this watershed analysis is built according to the requirements of *Ecosystem analysis at the watershed scale: a federal guide for watershed analysis* (REO 1995). This watershed analysis methodology is built up of six complementary parts. The first chapter is a watershed **characterization**, defining the characteristics that distinguish the watershed. The background laid out in this chapter leads to a set of **core topics and key questions** that have to do with watershed processes and their specific interactions with management activities. In response to these questions, the third and fourth chapter are constructed. The third chapter describes the **current conditions** within the watershed, while the fourth chapter reconstructs watershed processes and conditions under **reference conditions** (usually prior to European settlement). Based on the information provided in these chapters, we are able to synthesize the changes in watershed process that have been caused by various management activities. The results of this **synthesis** are included in the fifth chapter. Based on this synthesis, **recommendations** for current management and restoration are formulated.
As a level one analysis using the federal methodology, this watershed analysis report relies heavily upon data collected by other agencies and private sources. This particular watershed analysis report has relied extensively upon GIS analysis of publicly available data compiled by Interrain/Ecotrust as part of the Tualatin Basin compact disk that was prepared on behalf of the Tualatin River Watershed Council. These data have facilitated the analysis from these reports. However, they are not intended to replace field-based data for site-specific decisions. The data were analyzed for obvious flaws. However, no intensive review was performed on any data used in this report. There may be flaws in the source data and/or analysis performed in this report. This report should be used for general guidelines to point the direction to more site-specific studies.

Acknowledgements

Successful completion of the Dairy Creek watershed analysis report required the contribution of experts in many disciplines. The following primary team members contributed technical assistance, provided editorial review, and in many cases authored paragraphs specific to their fields of expertise.

Mike Allen, BLM, Project coordinator

Steve Bahe, BLM, Wildlife

Julie Fulkerson, USFWS, Wildlife

Walt Kastner, BLM, Silviculture

Gregg Kirkpatrick, BLM, Recreation

Bob McDonald, BLM, GIS

Dean Moberg, NRCS, Soils and agriculture

Andy Pampush, BLM, Survey and Manage species

Dave Roché, BLM, Silviculture

Larry Scofield, BLM, Vegetation

Lynn Trost, BLM, Roads

Warren Villa, Fire management

Matt Walker, BLM, Fisheries

Cindy Weston, BLM, Fisheries

Greg White, Tualatin River TAC, Fisheries

Dennis Worrel, BLM, Hydrology

People outside the primary team also made substantial contributions to the watershed analysis. Through his efforts, John McDonald, SWCD, facilitated the partnership between BLM and the SWCD that made this cooperative watershed analysis possible. Tracy Breinlinger and Fran Gray provided volunteer fieldwork. Jacqueline Dingfelder, formerly coordinator for the Tualatin River Watershed Council, provided assistance with watershed issues and supplied materials useful for preparation of the analysis. Finally, experts from many agencies provided information useful to the preparation of this report. Many thanks to all of these people for their assistance with the preparation of this watershed analysis report.

John Hawksworth

February 16, 1999

Chapter 1: Characterization

1.1 Physical

1.1.1 Size and setting

The Dairy-McKay watershed drains 231 square miles (147,956 acres) in the northern part of the Tualatin River basin (Map 1-1). It is the largest watershed contributing to the Tualatin River, constituting nearly one-third of the entire basin. From its headwaters in the Tualatin Mountains, the mainstem tributaries flow in a generally southerly direction, ultimately joining the Tualatin River at River Mile 45, near the city of Hillsboro, Oregon.

The watershed is drained by the mainstem Dairy Creek and three mainstem tributaries; the east and west forks of Dairy Creek and McKay Creek. Mainstem lengths and their drainage areas are given in Table 1-1. Stream mile indices, including tributaries, for these mainstem reaches are given in Appendix 1. The watershed is further subdivided into 38 subwatersheds (6^{th} field watersheds), which will be the basic unit for many analyses in this report (Map 1-2).

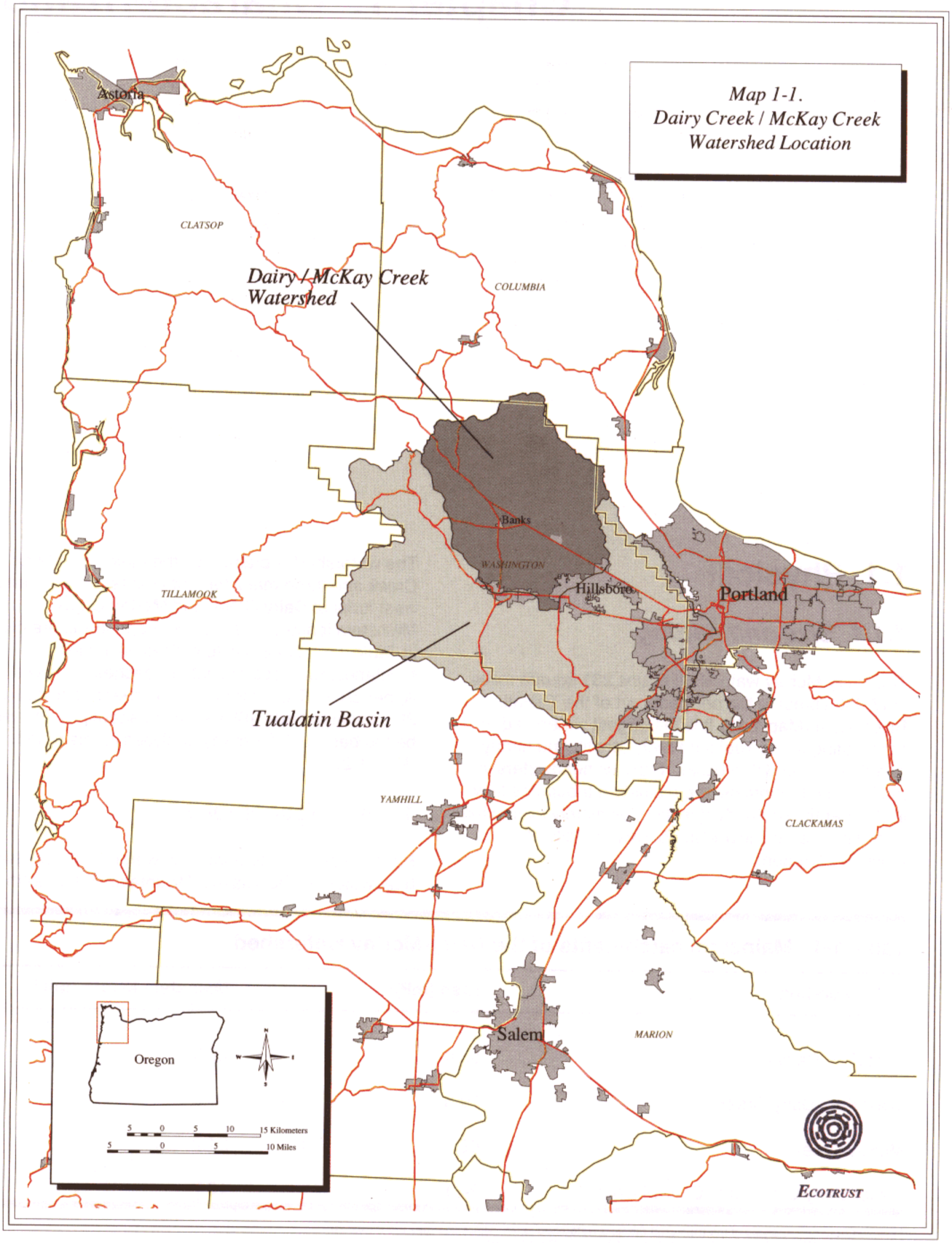
1.1.1.1 Topography

Most major streams within this watershed have their headwaters in the Tualatin Mountains to the north and

Table 1-1. Mainstem catchments of the Dairy-McKay watershed

Subwatershed	Area (mi^2)[1]	Mainstem length (mi) [2]
East Fork Dairy Creek	58.9	22.9
West Fork Dairy Creek	79.5	25.6
McKay Creek	68.5	24.2
Lower Dairy Creek (inc. Council Creek)	24.1	10.7

[1] Derived from GIS analysis of Interrain draft 6th field watershed layer. Minor changes are expected.
[2] Derived from GIS analysis of Interrain's digitized 1:24,000 stream layer.
[3] Measured from bluelines on USGS 1:24,000 topographic maps. The BLM GIS layer contains additional low-order streams not displayed on the USGS maps. Gradients of these tributaries are often greater than 10%.


Map 1-1.
Dairy Creek / McKay Creek
Watershed Location
Astoria
CLATSOP
COLUMBIA
Dairy / McKay Creek
Watershed
Banks
WASHINGTON
Hillsboro
Portland
TILLAMOOK
Tualatin Basin
YAMHILL
CLACKAMAS
Salem
MARION
Oregon
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5 0 5 10 Miles
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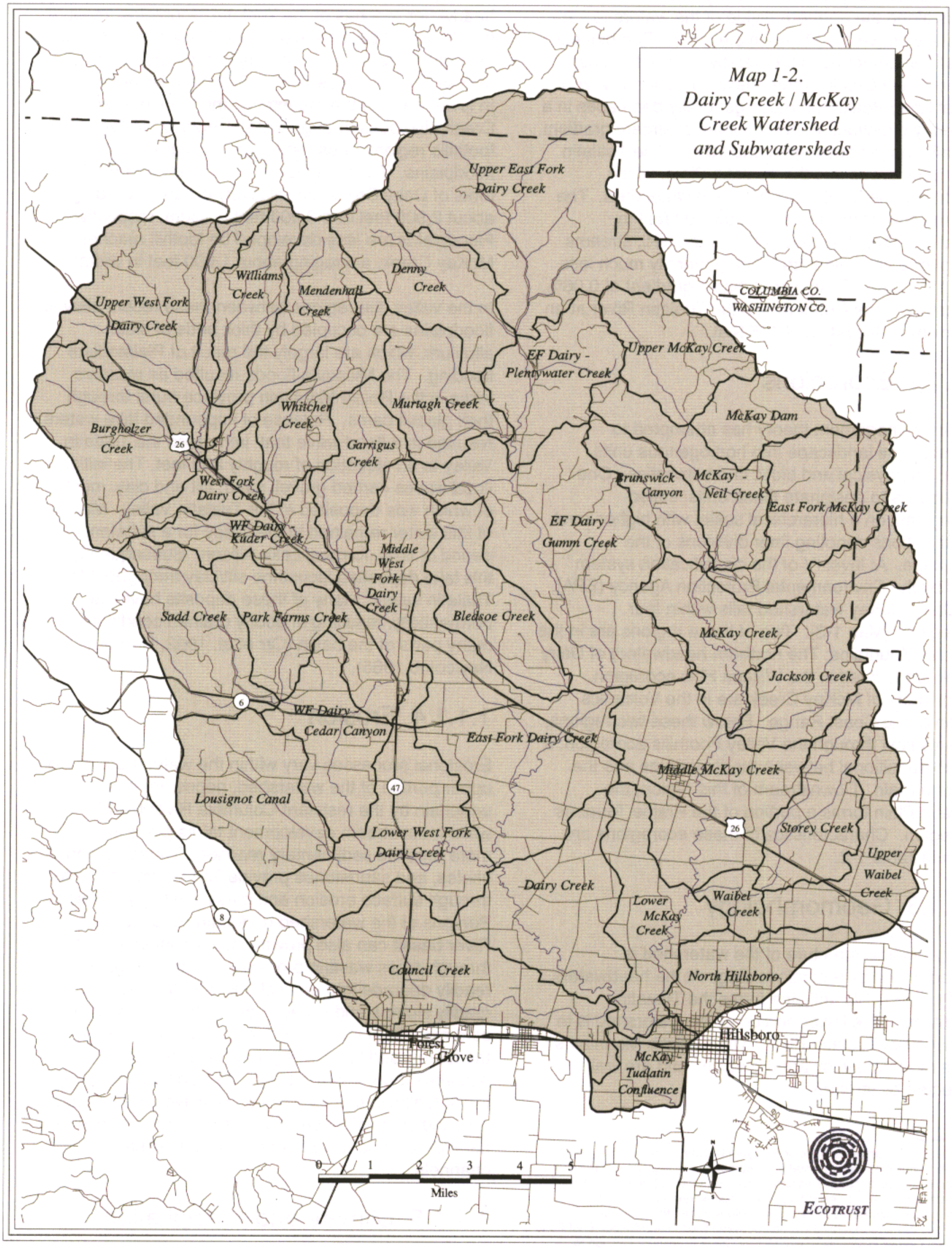
Map 1-2.
Dairy Creek / McKay Creek Watershed and Subwatersheds
Upper East Fork Dairy Creek
Upper West Fork Dairy Creek
Williams Creek
Mendenhall Creek
Denny Creek
COLUMBIA CO.
WASHINGTON CO.
Upper McKay Creek
EF Dairy - Plentywater Creek
Burgholzer Creek
Whitcher Creek
Murtagh Creek
McKay Dam
Garrigus Creek
West Fork Dairy Creek
Brunswick Canyon
McKay - Neil Creek
East Fork McKay Creek
WF Dairy - Kuder Creek
EF Dairy - Gumm Creek
Middle West Fork Dairy Creek
Sadd Creek
Park Farms Creek
Bledsoe Creek
McKay Creek
Jackson Creek
WF Dairy - Cedar Canyon
East Fork Dairy Creek
Middle McKay Creek
Lousignot Canal
Lower West Fork Dairy Creek
Storey Creek
Upper Waibel Creek
Dairy Creek
Lower McKay Creek
Waibel Creek
Council Creek
North Hillsboro
Forest Grove
Hillsboro
McKay Tualatin Confluence
0 1 2 3 4 5
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flow in a southerly direction through dissected terrain. Peaks along the northern divide of the watershed are generally above 1,500 feet in elevation. The highest elevations are found in the headwaters of the East Fork of Dairy Creek, where elevation reaches 2,265 feet at Long Peak. Elevation generally decreases in a southerly direction. In the mountains, stream gradient typically ranges between 3 and 10%[3]. The Tualatin Mountains grade into the Tualatin Plain, which constitutes the southern 30% of the watershed. The vast majority of this plain is below 200 feet in elevation. Over this part of the watershed, streams flow over a very slight gradient, generally much less than 1%. Lower Dairy Creek has a gradient of 0.06%. Ultimately, Dairy Creek meets the Tualatin River at an approximate elevation of 115 feet.

1.1.1.2 Ecoregions

Recent management theory has attempted to subdivide the landscape into homogenous units based on physical and biotic characteristics. One approach is to designate these units, called ecoregions, on a hierarchical scale, with higher level classifications denoting finer divisions of the landscape. At level IV of the classification system used by the Environmental Protection Agency (EPA), the Dairy-McKay watershed falls within four ecoregions (Map 1-3). Two of these regions are in the Tualatin Mountains: The northern headwaters of Dairy Creek are located in the Willapa Hills ecoregion. Headwaters of McKay Creek are in the Volcanics region of the Coast Range. Below these two regions, streams flow through the Valley Foothills ecoregion, a region transitional between the mountains and the Tualatin Plain. Downstream of this region, the Tualatin Plain forms a portion of the Prairie Terraces ecoregion. Characteristics of these ecoregions are given in Table 1-2.

1.1.1.3 Geomorphology

The geological structure of the watershed is characterized by tectonic folding. At the headwaters, the Portland Hills anticline forms the Tualatin Mountains. The lower portion of the watershed is in the synclinal Tualatin Plain. The Tualatin Mountains slope moderately toward the valley, and are well dissected by streams.

Lithology varies within the watershed (Map 1-4). In headwater reaches of the Tualatin Mountains, most of the West and East forks of Dairy Creek are underlain by Tertiary Marine sedimentary formations, while McKay Creek is underlain by Columbia River basalt. In lower parts of the mountains, the forks of Dairy Creek also pass through basalt lithology. In the foothills regions, these streams develop alluvial floodplains. The floodplains of the West and East forks of Dairy Creek are relatively broad, averaging about 2,900 feet and 3,900 feet in width, respectively. Floodplains are less developed on foothill reaches of McKay Creek, averaging about 1,900 feet in width[4].

In the valley, the regions between these recent alluvial floodplains are occupied by thick beds of older alluvium, which are largely the result of Pleistocene flooding. The Missoula floods resulted as massive lakes in the Rocky Mountain province burst through their glacial dams. Release of impounded lake waters resulted in a flood wave that immersed the Tualatin Valley to an elevation of roughly 250 feet. The initial flood waves carried gravel, sand, silt and clay, much of which was deposited in the Tualatin Valley. Much of this water remained in the valley for a substantial period of time, forming Lake Allison. Subsequently, this lake deposited lacustrine silt/clay throughout the Tualatin valley. Many of these deposits have low permeability, resulting in poorly drained conditions in many parts of the basin (Orr et al. 1992, Hart and Newcomb 1965).

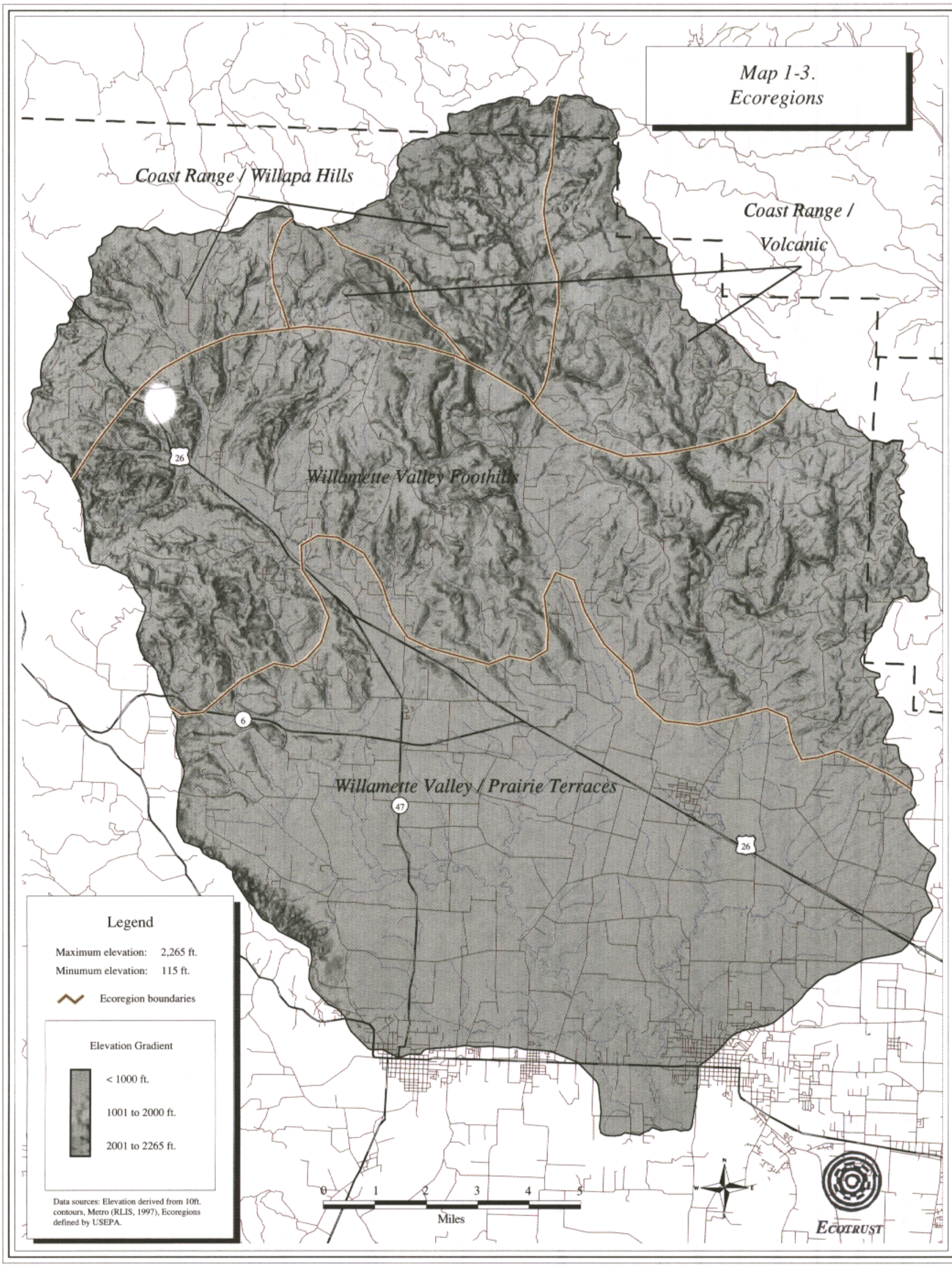
1.1.1.4 Erosion

Erosional processes vary within the watershed. In the upper portion of the watershed, ridges are often underlain by the resistant Columbia River basalt, while most stream development takes place in the more erodible sedimentary reaches. These siltstones, shales, and sandstones provide fine sediments, both through surface erosion and mass wasting processes. Portions of the watershed underlain by Columbia River basalt can also provide substantial sediments through mass wasting processes. These basalts readily degrade into an unstable lateritic soil, which readily slumps and slides. Landslides are especially common along the steep inner gorges of streams. In the foothill and terrace regions, streambank erosion becomes a dominant process, as fluvial action erodes the soft alluvium of the banks. However, the cohesive silts and clays of these regions provide resistance to bank erosion, leading to deep, narrow, stream channels.

1.1.1.5 Climate and Precipitation

The Tualatin basin lies in a region of moderate

[4] Derived by GIS analysis of Geology layer (Tualatin compact disk). For the analysis, floodplains were defined as stream-adjacent regions underlain by Quaternary Alluvium (Qal). This area varies from the 100 year floodplain. The foothills region was defined as that portion where these stream floodplains were bordered by bedrock lithology, rather than alluvium. On the West Fork, this was roughly the reach between Buxton and Banks; East Fork, Meacham Corner to Mountaindale; McKay Creek Brunswick Canyon to Jackson Creek. Width was calculated as polygon (area/length).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Data sources: Elevation derived from 10ft. contours, Metro (RLIS, 1997), Ecoregions defined by USEPA.
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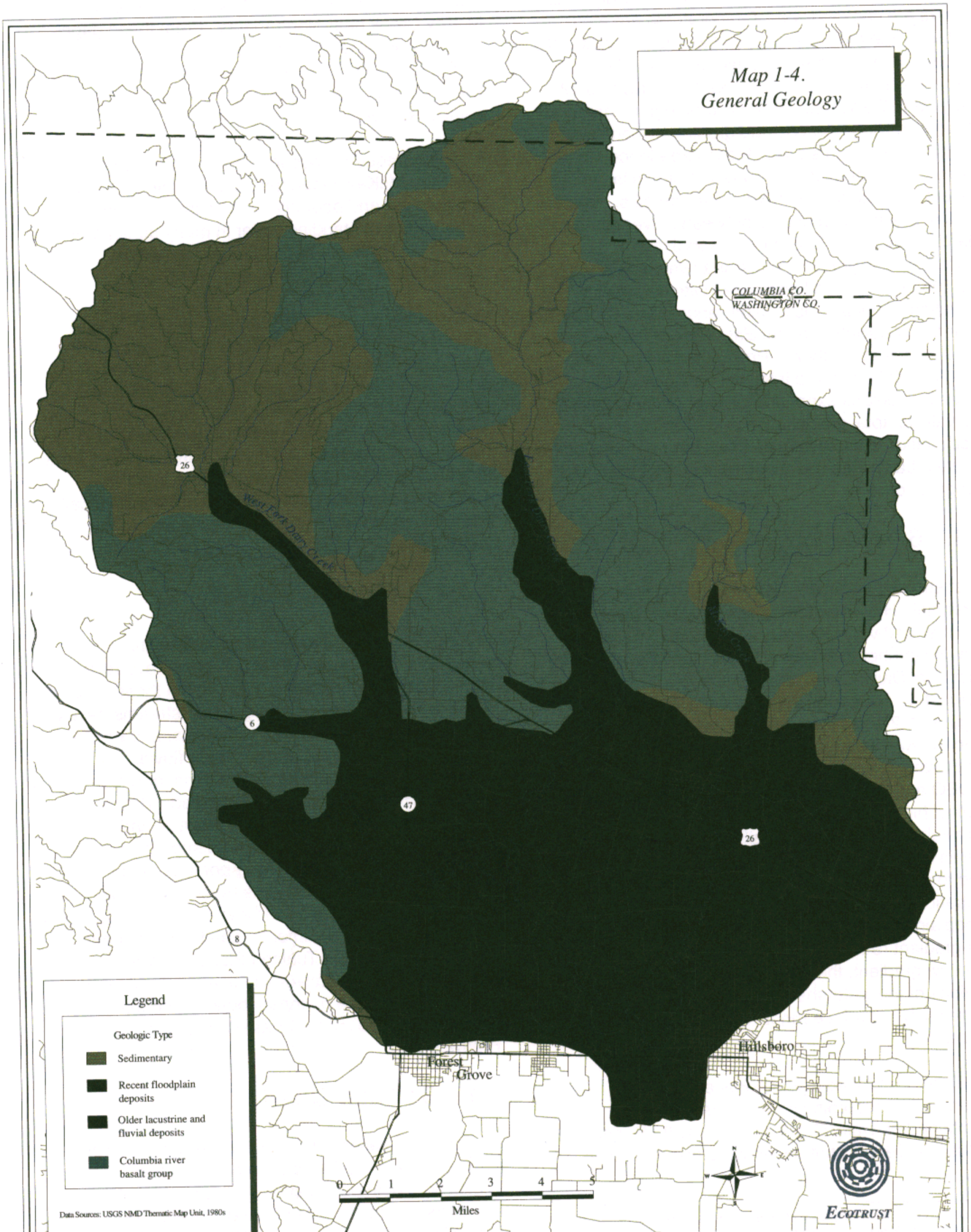
Table 1-2. Characteristics of EPA Level IV ecoregions in the Dairy Creek watershed. (Adapted from Pater et al. 1998, NRCS 1982)

Level IV ecoregion	Elevation (feet)	Physiography	Lithology	Soil orders	Common soil series	Potential natural vegetation	Land use	Climate
1d. Volcanics	400-2,200	Steeply sloping mountains. Moderate to high gradient streams with stable summer flow.	Columbia River basalt. Minor inclusions of sedimentary rock.	Andisols, Ultisols	Cascade, Cornelius, Goble, Saum, Delena	Western hemlock, western redcedar, Douglas-fir	Forestry, rural residential development, recreation.	Mesic/Udic
1f. Willapa Hills	500-2,300	Low, rolling hills and mountains with medium gradient, sinuous streams and river. Low drainage density.	Tertiary marine sedimentary rocks, mostly sandstone and siltstone.	Andisols, Ultisols, Inceptisols	Olyic, Melby, Pervina, Knappa, Tolke, Udifluvents	Western hemlock, western redcedar, Douglas-fir	Forestry, rural residential development, pastureland.	Mesic/Udic
3c. Prairie Terraces	115-200	Nearly level to undulating fluvial terraces with sluggish, meandering streams and rivers. Historically, seasonal wetlands and ponds were common. Many streams now channelized.	Pleistocene lacustrine and fluvial sedimentary deposits.	Alfisols, Mollisols, Inceptisols	McBee, Chehalis, Wapato, Verboort, Cove, Labish, Woodburn, Quatama, Willamette, Aloha, Amity, Dayton	Oregon white oak, prairies. In wetter areas: Oregon ash, Douglas-fir.	Agriculture. Also urban/ rural residential development and some forested riparian zones.	Mesic/Xeric
3d. Valley Foothills	200-1,800	Rolling foothills with medium gradient, sinuous streams.	Miocene andesitic basalt and marine sandstone.	Alfisols, Ultisols, Mollisols, Inceptisols	Chehalis, Cornelius, Kinton, McBee, Melbourne, Saum	On drier sites: Oregon white oak. In moister areas: Douglas-fir more common. Some western redcedar.	Rural residential development, pastureland, coniferous and deciduous forests, forestry, vineyards, Christmas tree farms, orchards.	Mesic/Xeric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Older lacustrine and fluvial deposits
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Miles
Data Sources: USGS NMD Thematic Map Unit, 1980s
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climate. Summers are warm and generally dry, while winters are cool and wet. Temperatures are moderated by the moist climate. In the Tualatin Valley, the freeze-free growing season averages 180 days, and the temperature falls below freezing 65 days out of the year (SCS 1982). Mountainous regions have shorter growing seasons and greater incidence of freezing temperatures than those experienced in the valley. Weather is often cloudy, but precipitation is generally concentrated in the winter months. Roughly 72% of precipitation occurs between November and March (Figure 1-1)[5]. Generally speaking, precipitation is greatest in the headwaters regions of the Tualatin Hills, and decreases with decreasing elevation. Annual precipitation ranges from 67 inches near the headwaters of the East Fork of Dairy Creek to 38 inches at Hillsboro. Precipitation is generally light, with little raindrop intensity. Although the mountain regions experience higher precipitation than the valleys, total precipitation and intensity of precipitation are low relative to western portions of the Tualatin basin, such as those drained by Gales and Scoggins creeks.

1.1.1.6 Hydrology

Most streams within the Dairy-McKay watershed are perennial. However, flow is seasonal, with high peaks in winter and very low flows in summer. The period from November to March accounts for 79% of flow in East Fork Dairy Creek, and 87% in

Figure 1-1. Precipitation at Hillsboro McKay Creek (Figures 1-2 and 1-3)[6]. Unlike Gales Creek, the Dairy-McKay watershed does not contribute extensively to flood peaks on the mainstem Tualatin (ODEQ and USA 1982). Several factors mitigate against high runoff. This watershed lacks high mountains and intense rainfall, and rain on snow events are rare. Additionally, forested portions would tend to reduce surface runoff through interception and infiltration. Flood peaks are further attenuated by floodplain storage during their long journey through low-gradient reaches in the Tualatin Plain. Due to their low gradient, the alluvial areas at the lower portions of the watershed do not contribute appreciably to surface runoff, except near stream channels.

Few long-term hydrologic records exist for the watershed. A recording gage is seasonally maintained on Dairy Creek at Highway 8. During the 1940s and 1950s, staff gages were maintained on East Fork Dairy Creek near Mountaindale, and on McKay Creek near North Plains. From these gages, a mean annual discharge of 107 cfs was calculated for the East Fork Dairy site, and 70 cfs for the McKay site. However, differing periods of record limits comparison between these two gages.

Flooding frequently occurs in the alluvial portions of the Dairy-McKay watershed. During rainfall events, low gradient and poor infiltration combine to create large bodies of standing water in many portions of the alluvial plain. Some of these areas provided substantial wetlands in historical times.

Both unconfined and confined aquifers provide groundwater to the Dairy-McKay watershed. For the most part, the area lacks large aquifers, although some groundwater units are locally important for municipal and irrigation purposes. The most significant aquifers occur in the Columbia River basalt. Interspersed sand layers in the Hillsboro area provide important unconfined aquifers (Orr et al. 1992, Hart and Newcomb 1965). Additionally, locally perched water tables occur on clay lenses in the watershed.

1.1.1.7 Stream Channel

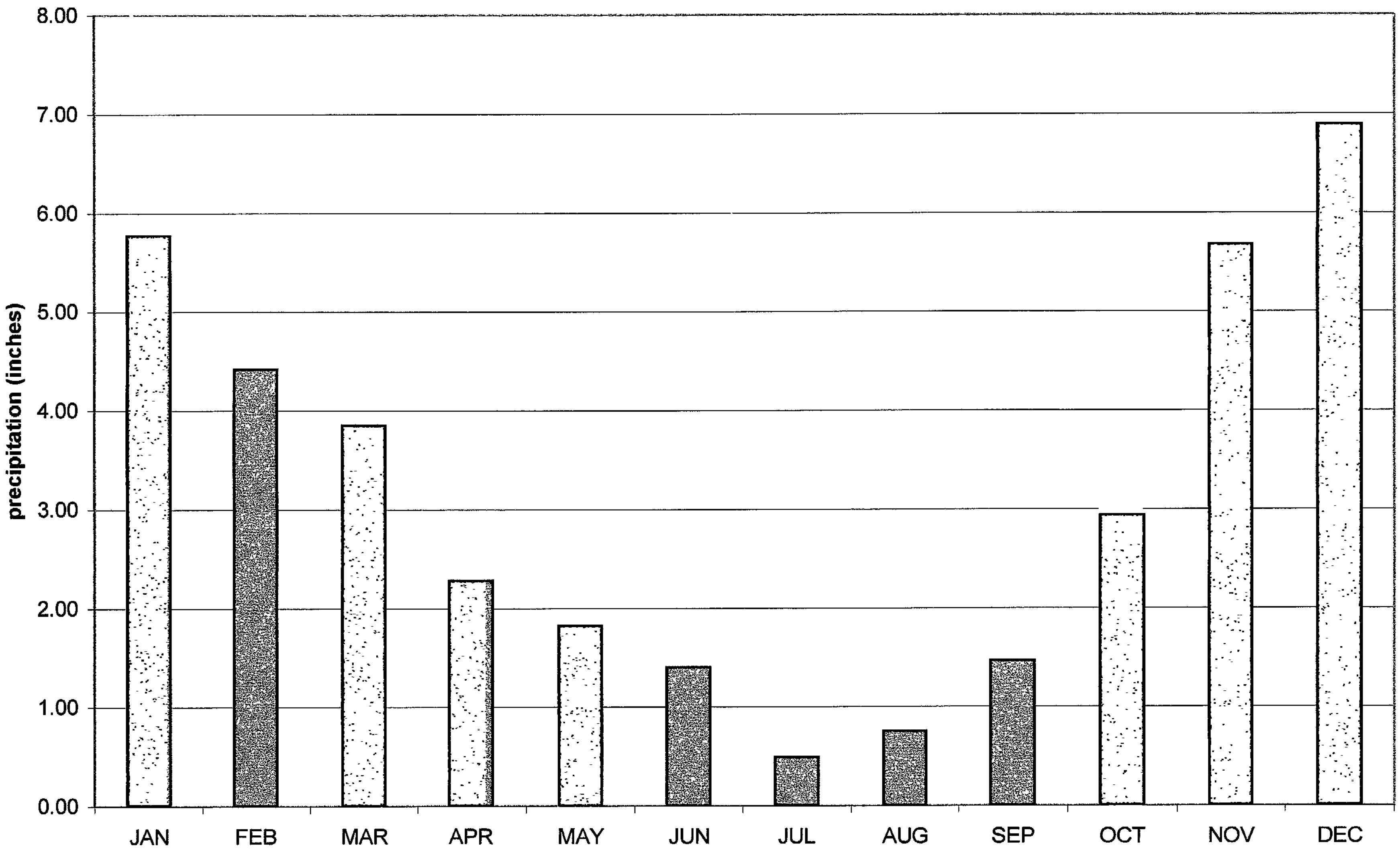
Stream channels vary with topography within the watershed. The upper stream reaches have relatively high gradients. Typical gradients within these reaches average 3-10%. These high gradient streams have a substantial capacity to carry sediments, and erosion and sediment transport are dominant fluvial processes. Under high flow conditions, only the larger sediment fractions are deposited. These reaches tend to have a cobble substrate, and previous surveys have found pools and riffles to be well distributed within the upper portions of the watershed. When the streams reach the alluvial plain, gradient decreases. The streams become less competent to carry sediments, and finer sediments are deposited. In the Tualatin Plain, the dominant substrate gradually converts to fine sand, silt, and clay. Generally, the boundary between cobble and fine substrates follows an East-West line north of Highway 26.

1.1.1.8 Water Quality

Recently, increased attention has been focused on water quality in the Tualatin River watershed. Legislation, both on the state and federal level has mandated improvements in water quality. For example, the Federal Clean Water Act requires implementation of Total Maximum Daily Load (TMDL)

[5] Based on precipitation records at Hillsboro and Forest Grove
[6] Based on ODWR estimates from a very short period of record. Records for McKay Creek were taken 1940-1943, and 1948-1956. Records for E.F. Dairy from 1941-1951.

Figure 1-1. Hillsboro: Rainfall distribution by month



standards for parameters limiting water quality. In 1987, TMDL standards were implemented in the Tualatin Basin for ammonia nitrogen and phosphorus. More recently, Senate Bill 1010 prohibited certain conditions leading to diminished water quality (Appendix 3). Implementation of environmental legislation, has required monitoring of water quality. Monitoring by the Oregon Department of Environmental Quality (ODEQ), Unified Sewerage Agency (USA), and several other public agencies and private organizations has been conducted at many locations within the watershed.

In response to the requirements of the Federal Clean Water Act, the state of Oregon produced the 303(d) list, which identifies streams with water quality limitations potentially impacting beneficial uses. Several streams in the Dairy-McKay watershed are on this list. These include

- Council Creek, where dissolved oxygen is considered limiting to cool water aquatic life from May to October;
- Dairy Creek below the confluence of the east and west forks. This reach of Dairy Creek has excessive *E. coli* counts year-round, and has summer temperatures which are limiting to cool-water aquatic life;
- East Fork Dairy Creek, from the mouth to Whisky Creek, where summer pH is frequently lower than the desired range of 6.5-8.5. In 1998, summer water temperature was also found to be limiting to cool-water aquatic life on this stream;
- West Fork Dairy Creek, which has high *E. coli* counts in summer. In 1998, summer water temperature was also found to be limiting to cool-water aquatic life on this stream;
- McKay Creek, from the Mouth to East Fork, summer water temperatures are a concern. Additionally, high *E. coli* levels prevail throughout the year.

Many of these streams also were considered for listing due to pesticide levels and sedimentation. Due to insufficient data, these factors did not cause any streams to be added to the 1998 list. As additional information becomes available, sediment and pesticide levels may become the source of future listings.

There is evidence that water quality in streams above these 303(d) listed reaches is generally good, although water temperatures may exceed the 17.8C cool-water standard for salmonids periodically during the summer. In 1975 and 1976, B. Sutherland, ODEQ, performed a macroinvertebrate study on upper McKay Creek and the East Fork of Dairy Creek and found high species diversity, including species sensitive to water quality conditions (Sutherland 1976). Although these surveys are 20 years old, it is likely that the current water quality supports similar populations, as the Water Quality Index (WQI)[7] for these streams has improved over that period.

1.1.1.9 Soils

The soils of the Dairy-McKay watershed are largely influenced by their parent material. In the Tualatin mountains, the sedimentary formations typically produce Alfisols and Inceptisols. These soils are typically fine grained with a large silt component. Texturally, they are typically moderately to very deep loams.

The Columbia River basalt typically produces Andisols and Ultisols. Texturally, these soils occur in a wide variety of loams. In Oregon's moist climate, the Columbia River basalt readily decomposes into a deep, red, lateritic, erodible, unstable soil (Hart and Newcomb 1965). This soil is readily erodible, resulting in a dissected terrain (Orr et al. 1992). Such dissection is particularly notable in the McKay Creek drainage.

Soils in the Tualatin Plain are typically made of fine alluvium in the silt and clay classes. Coupled with low slopes, this often leads to areas of poor drainage. Historically, large wetlands occupied many of these areas.

Some soils in the valley are rich in phosphorus. In some cases, high phosphorus levels may indicate accumulation over many years from agricultural use. However, groundwater phosphorus levels in the Tualatin Valley are naturally quite high, potentially resulting in high soil phosphorus levels (TAC 1997). Similarly, soil phosphorus levels in forested regions tend to reflect natural groundwater content (Wolf 1992). Forest soils developed on sedimentary lithology, in particular, have naturally high phosphorus content (Miller and McMillen 1994).

[7] The WQI was developed by ODEQ as a composite index of water quality. The component parameters of the WQI are temperature, dissolved oxygen, five-day biochemical oxygen demand, pH, total solids, ammonia +nitrate nitrogen, total phosphorus, and fecal coliform. A description of the procedure for determining WQI is found in Aroner 1998.

Figure 1-2. Mean Discharge, East Fork Dairy Creek at Mountaindale, October 1940-September 1951

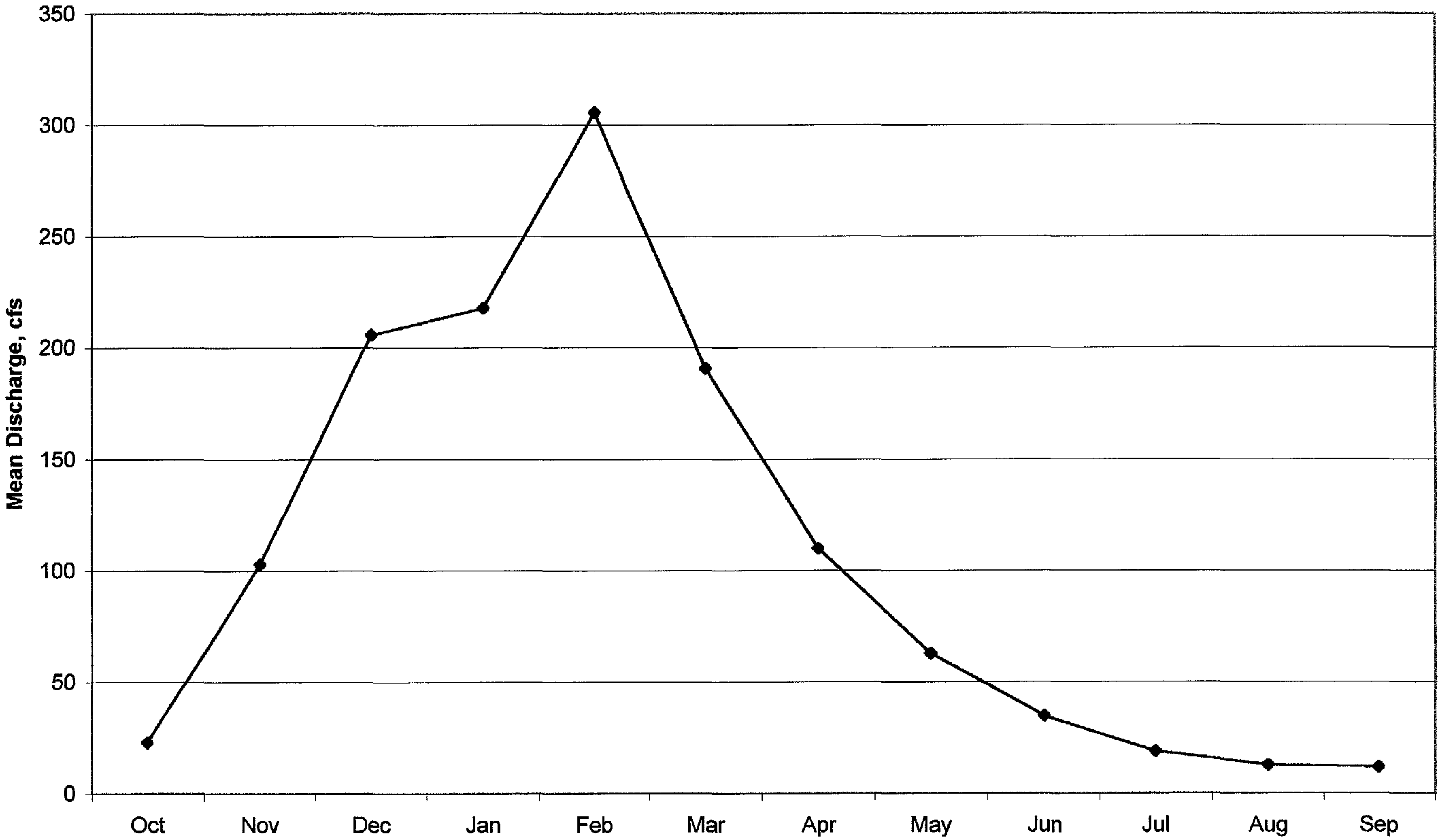
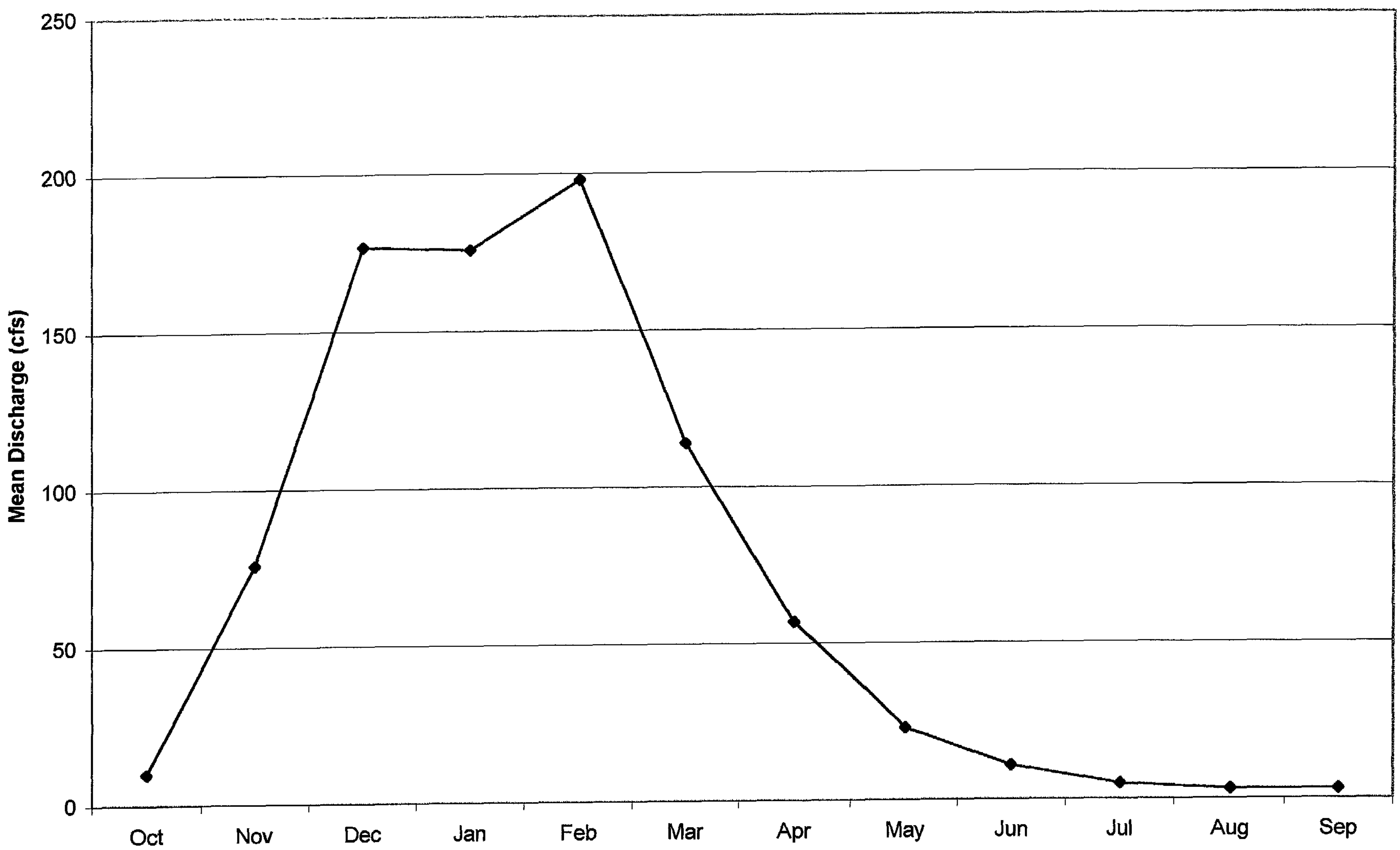


Figure 1-3. Mean Discharge, McKay Creek near North Plains, October 1940-September 1956.



1.2 Biological

1.2.1 Vegetation characteristics

Vegetation in the mountains is dominated by conifers, typically Douglas-fir (*Pseudotsuga menziesii*). Associated conifers include western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*). Hardwoods stands dominated by red alder (*Alnus rubra*) are common in riparian areas. Red alder is also common on disturbed sites. Bigleaf maple (*Acer macrophyllum*) is typically abundant on canyon walls, and often occurs as a minor stand component in upland Douglas-fir forests and drier portions of riparian forests. Similar species occur in the foothills, with Oregon white oak (*Quercus garryana*) becoming present in drier locations. The Tualatin plain itself is primarily used for agriculture. The vegetation consists mainly of wheat, orchards, and row crops.

Occasional patches of Douglas-fir and Oregon white oak, along with grasslands, are interspersed with the agricultural areas. Riparian zones in the lower reaches of the Dairy-McKay system are often dominated by Oregon ash (*Fraxinus latifolia*). Where riparian tree species do not provide an overstory, the streambanks are often dominated by shrubs such as the native red-osier dogwood (*Cornus stolonifera*) and the introduced invasive Himalayan blackberry (*Rubus procerus*).

Weed species present problems in many parts of the watershed, particularly in disturbed areas. The species of greatest abundance is Himalayan blackberry, which is nearly universal in ruderal habitats and along disturbed portions of streambank. Reed canarygrass (*Phalaris arundinacea*) is also abundant in moist, disturbed areas in the watershed. Other species of concern include Scotch broom (*Cytisus scoparius*) and various thistle species.

Several vegetational species bear special concern under BLM guidelines. Some of these species have a limited range, while others are diminished from their original numbers. Sensitive botanical species likely to inhabit the Dairy-McKay watershed are listed in Table 1-3. Additional discussion of sensitive species is found in section 1.2.2.1.1.

1.2.2 Species and Habitat

1.2.2.1 Species

1.2.2.1.1 Economically important and ecologically sensitive species

Dairy and McKay creeks are home to diverse animal species. Some of these species attract extra attention due to biological, recreational, or economic factors. These include game species, such as deer and elk, which are important for recreational hunting.

The Northwest Forest Plan (NFP) directed federal agencies to devote special management attention to certain plant and animal species on federal lands[8]. These included species listed as Endangered or Threatened under the Endangered Species Act (ESA), as well as those species considered to be sensitive under state or BLM guidelines.

A large number of the Special Attention Species fall within the Survey and Manage directive of the NFP. Of the over 1000 species whose viability was assessed through the federal Scientific Analysis Team and Forest Ecosystem Management Assessment Team (FEMAT) efforts, it was determined that slightly more than 400 of those species would benefit from extra management provisions. Thus, the Survey and Manage standards and guidelines were developed and adopted as part of the Forest Plan to reduce the possibility of loss of population viability of those species of concern through the implementation of federal actions.

There are four components to the Survey and Manage standards and guidelines and each species is assigned to one or more of the component categories. The component categories are:

1. *Manage known sites.* This component, which went into effect in 1995, requires federal agencies to acquire and use information on known sites of Component 1 species when planning and implementing projects. The most appropriate action in most cases is the protection of relatively small sites but in the case of a few species the protection of fairly extensive areas may be warranted.

[8] A list of these Special Attention Species is given in the *Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl* (SEIS) of the NFP.

2. *Survey prior to ground disturbing activities.* There are 77 Component 2 species that require surveys prior to implementing activities that may disturb the habitat of those species. Survey protocols for these species were to have been developed and surveys completed for projects to be implemented in Fiscal Year 1999 or later. Due to the difficulty of developing field survey protocols for some species, not all protocols are in place as of the beginning of Fiscal Year 1999. There are 32 or the 77 species that cannot be readily identified and/or do not fruit often enough to be adequately surveyed for in a single year. The federal agencies are currently undertaking an effort to reclassify these species into either Component 3 or Component 4 categories, where other survey schedules or techniques may prove more effective for those species.

3. *Extensive surveys.* Broad surveys would be conducted to find high-priority sites for species management. This component is primarily for species whose life histories are such that they may only be found or can be identified when specific climatic conditions exist. Protocols would be developed for these species and surveys for some species would be underway by 1996.

4. *General regional surveys.* The objective of this component is to survey to acquire additional knowledge of poorly understood species and to determine necessary levels of protection. The species intended to benefit from this standard and guideline are the arthropods, bryophytes, lichens, and those fungi species that were not classed as rare and endemic.

1.2.2.1.2 Aquatic species

Several native salmonid species inhabit the watershed, including steelhead trout (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*). Although coho salmon (*O. kisutch*) is not native, they have been introduced and now spawn naturally within the watershed and are considered an important species.

Much of Dairy and McKay creeks contain salmonid habitat. Fisheries surveys conducted by the Oregon Department of Fish and Wildlife (ODFW) found salmonids in most surveyed streams in the watershed. Resident cutthroat trout, in particular, are distributed throughout much of the watershed. The amount of habitat available to anadromous salmonids is more limited.

Abundance of salmonid species is a matter of concern. Steelhead trout within the Upper Willamette Evolutionarily Significant Unit (ESU), which includes the Tualatin Basin, are proposed for listing as threatened under the federal Endangered Species Act (ESA). Additionally, coastal cutthroat trout are a candidate species for listing under the ESA. These species are also on ODFW sensitive species lists.

Many native non-salmonid species are present in the watershed, including sculpin, lamprey, and dace. The torrent sculpin (*Cottus rhotheus*), a species particularly intolerant to poor water conditions, was found in 1994 in the East Fork of Dairy Creek near Little Bend, indicating generally good water quality (Ward 1995).

1.2.2.2 Habitat

1.2.2.2.1 Wildlife Habitat (terrestrial)

Wildlife habitat has changed along with changes in the vegetation of the basin. Most vegetation in the Dairy-McKay watershed is predominantly in early and mid-successional seral stages, and structurally quite fragmented. Late seral habitat exists in very small patches. The patchiness of the current landscape is favorable to production of game species, such as deer, and other "edge" species.

On the other hand, these changes have created less favorable conditions for species dependent upon late-successional vegetation. Many of these species require habitat elements most commonly found in old-growth forest, such as snags and down wood. Bats, for example, use snags and down wood for roosting sites. Changes in forest structure have reduced the availability of these habitat elements. The effect of these changes varies by species. The watershed is no longer suitable for production of species with large home ranges, such as spotted owls. Other species, such as the marbled murrelet, have also experienced greatly diminished habitat, but remaining small patches of forest bearing late-successional elements can provide suitable habitat for these species.

Riparian habitat has become degraded in many parts of the watershed. The ability to provide large woody debris has been reduced, resulting in a reduction of the number and size of pools. Many of the large trees that formerly surrounded streams have been cleared, resulting in reduced canopy and increased summer water temperatures. The weedy shrub species, such as Himalayan blackberry, that have replaced these trees in many sites are unable to provide adequate stream shading.

Table 1-3. Threatened/endangered/sensitive plant species potentially found in the Dairy-McKay watershed.

Listed under ESA	
Sidalcea nelsoniana	Nelson's checkermallow
Howellia aquatilis	Howellia
Lomatium bradshawii	Bradshaw's lomatium
Bureau Sensitive (BLM Manual 6840)	
Agrostis howellii	Howell's bentgrass
Castilleja levisecta	Golden paintbrush
Cimicifuga elata	Tall bugbane
Delphinium leucophaeum	White rock larkspur
Delphinium pavonaceum	Peacock larkspur
Filipendula occidentalis	Queen-of-the-forest
Lupinus sulphureus ssp. Kincaidii	Kincaid's lupine
Assessment Species (BLM Manual 6840)	
Carex livida	Pale sedge
Carex retrorsa	Retrorse sedge
Dryopteris filix-mas	Male fern
Fritillaria camschatcensis	Indian rice
Isopyrum stipitatum	Dwarf isopyrum
Lycopodium complanatum	Ground cedar
Polystichum californicum`	California sword fern
Wolfia borealis	Dotted water meal
Tracking Species (BLM Manual 6840)	
Bergia texana	Texas bergia
Elodea nuttallii	Nuttall's waterweed
Eriophorum polystachion	Many-spiked cottongrass
Euonymus occidentalis	Western wahoo
Hieracium canadense	Canadian hawkweed
Juncus kelloggii	Kellogg's dwarf rush
Lathyrus holochlorus	Thin-leaved peavine
Lycopodium annotinum	Stiff club moss
Montia diffusa	Branching montia
Poa laxiflora	Loose-flowered bluegrass
Poa marcida	Weak bluegrass
Sidalcea campestris	Meadow sidalcea
Trillium parviflorum	Small-flowered trillium

Note: Additionally, there are many "Survey and Manage" plant species that could be found on these watersheds. These species are listed in Appendix J2 of the Northwest Forest Plan and the Salem District Resource Management Plan.

1.2.2.2.2 Aquatic Habitat

The suitability of aquatic habitat for sensitive cold water species is quite variable. Fine substrate, high temperatures, and low dissolved oxygen limit the ability of the lower mainstem of Dairy Creek to provide suitable summer rearing habitat for salmonids. Tributary reaches in the Tualatin Plain bear similar concerns.

In the foothills and mountains, salmonid habitat improves. In ODFW surveys conducted in the 1980's, McKay Creek and both forks of Dairy Creek were found to have suitable spawning gravels for salmonids (SRI 1989). Habitat surveys conducted by BLM in 1994-95 found fair to poor salmonid habitat in the upper reaches of Dairy Creek. No habitat surveys have been conducted subsequent to the flood events of 1996.

1.2.2.2.3 Special Habitats

Certain habitat types in the watershed have special significance through their rarity in the watershed and their importance to sensitive species. One such habitat type is forest with late-successional characteristics[9]. This habitat type can be found in patches, mainly distributed in headwater reaches of the watershed. On federal lands, the Big Canyon Late Successional Reserve (LSR) has the greatest contiguous stand of this habitat type.

Another important habitat type is wetland habitat. In the Tualatin Mountains, wetland types are generally represented by small ponds built by beavers. Larger wetlands are located in the Tualatin Plain. Most of these wetlands are located near the West Fork of Dairy Creek. Portions of Jackson Bottom, south of Hillsboro, also fall within the watershed boundaries. Although none of these wetlands fall into preserves, they provide important habitat for a number of aquatic, amphibian, and avian species.

1.3 Social

1.3.1 Population

Population within the Dairy-McKay Creek watershed is concentrated in the urbanized southern portion of the watershed (Map 1-5). Incorporated cities wholly or partially within the Dairy Creek drainage (with estimated 1997 population) include Hillsboro (58,365), Forest Grove (15,965), North Plains (1,655), Cornelius (7,845) and Banks (625). The growth of the Portland metropolitan area and increasing employment in high technology contributed to rapid population growth within the watershed. To accommodate the increased population, an urban growth boundary (UGB) has been designated. If the present urban growth boundary remains constant, most future development will take place along the Highway 8 corridor in Hillsboro, Cornelius, and Forest Grove, and is most likely to affect Council Creek and the lower portions of Dairy and McKay creeks.

The present urban growth boundary encompasses 10.79 square miles within the watershed, an increase of 34% over 1997 city limits[10]. As these cities grow, most new development will take place on lands that were traditionally agricultural.

1.3.2 Ownership

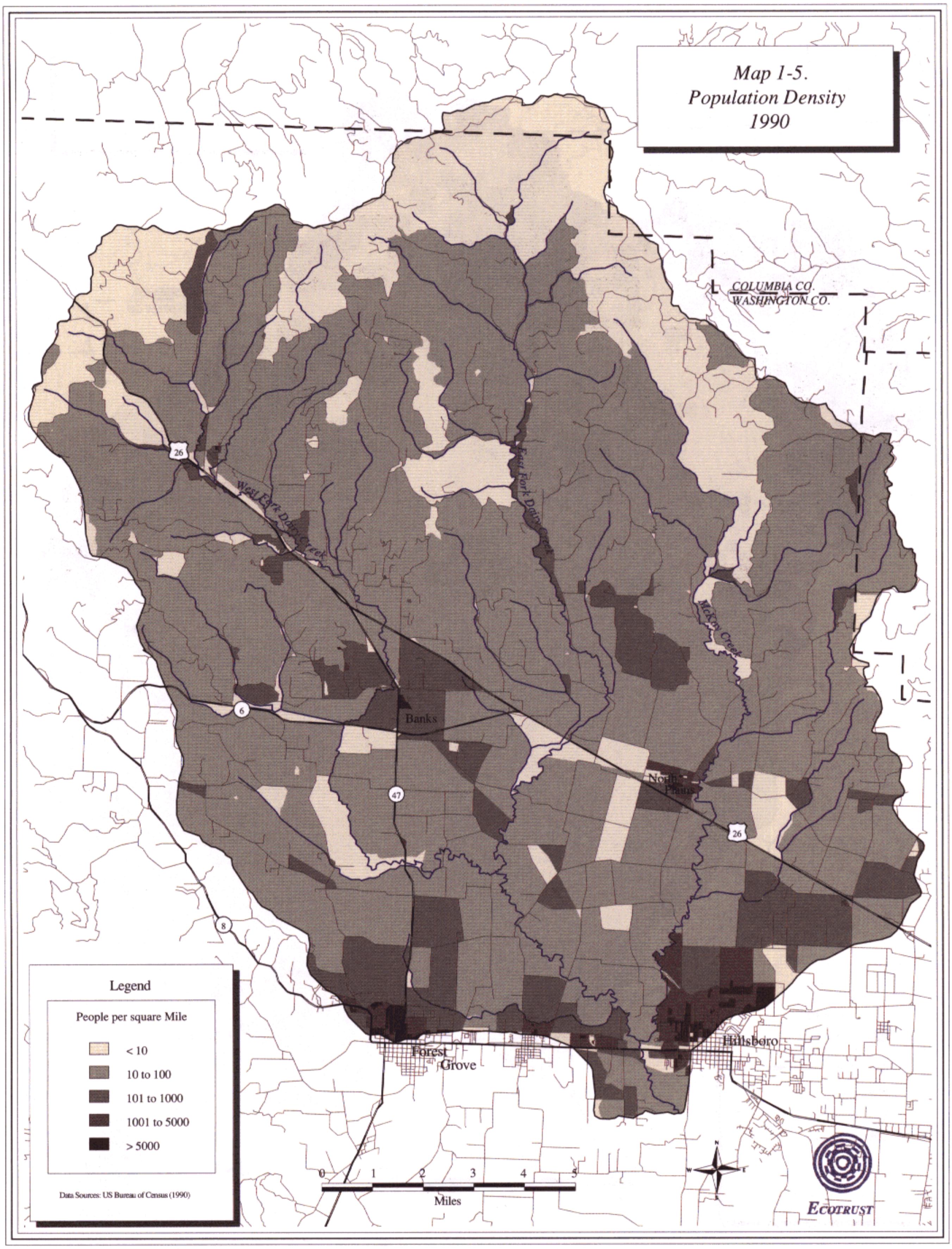
Land in the Dairy-McKay watershed is primarily privately owned (Map 1-6). About 95% of the watershed is in private ownership: 27,400 acres (18.7%) is private industrial timberland, and 112,700 acres (76.2%) in other private lands[11].

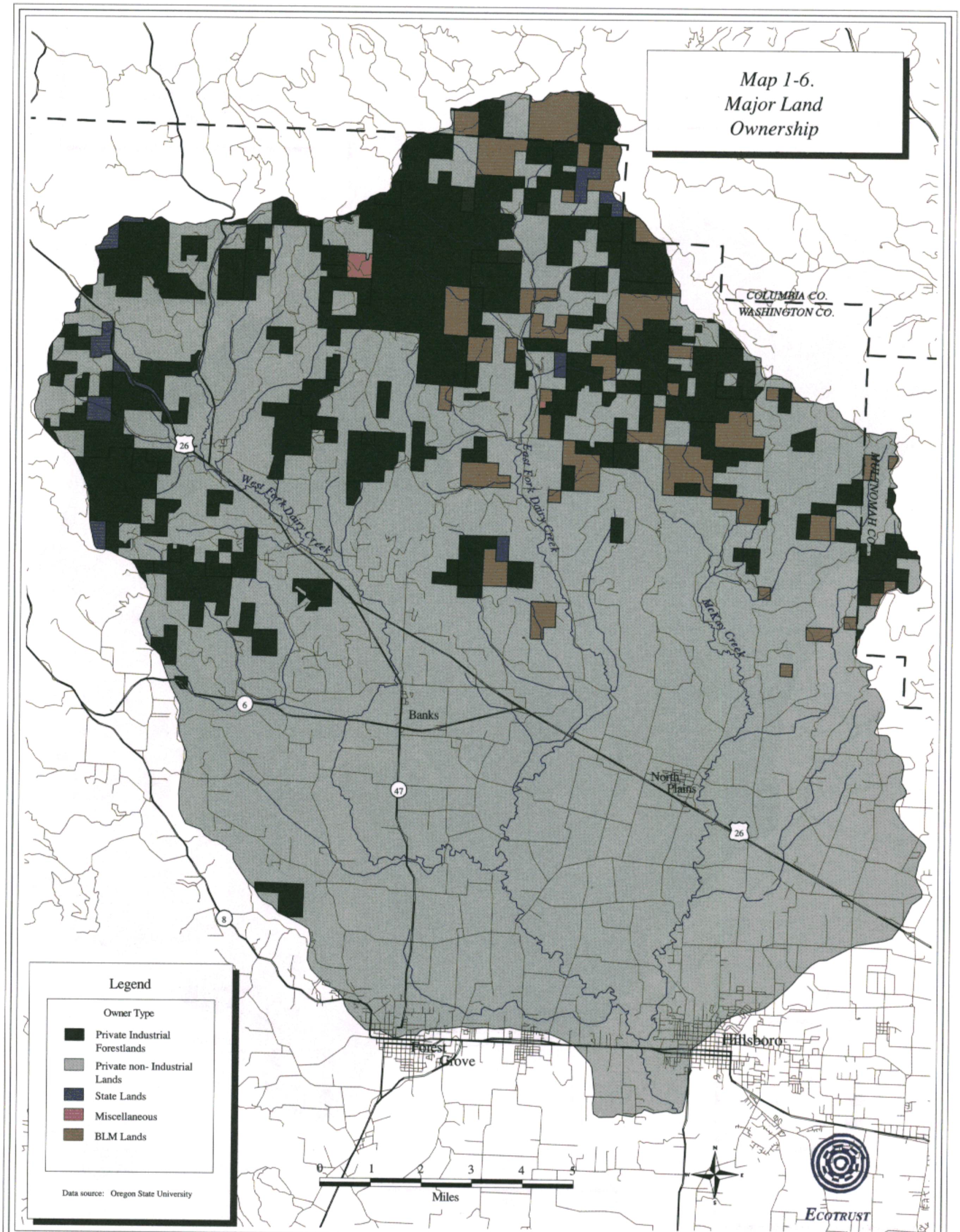
Public land managed by the Bureau of Land Management (BLM) makes up most of the remaining land within the Dairy-McKay watershed. BLM holdings comprise 6,521 acres of forested land, roughly 4.4% of the watershed. Most of these lands are Oregon and California Railroad (O&C) lands. Due to this legacy, these lands are distributed in a patchy fashion, rather than a single block. federal statutes direct the BLM to manage O&C lands for sustained yield forestry in a manner consistent with federal environmental objectives. Other public lands are managed by the State of Oregon, Washington County, and various municipalities.

[9] "Four major structural attributes of old-growth Douglas-fir forests are: live old-growth trees, standing dead trees (snags), fallen trees or logs on the forest floor, and logs in streams Additional important elements typically include multiple canopy layers, smaller understory trees, canopy gaps, and patchy understory." (NFP page B-2)

[10] Derived from GIS analysis of Metro's 1997 UGB and City boundary coverages. If the UGB were to be completely developed, it would also represent a 70% increase over 1996 watershed development levels. However, these numbers are not directly comparable, as the 1996 data contain developed areas outside the UGB.

[11] Derived from GIS analysis of the 1995 OSU layer showing timberland ownership.


Map 1-5.
Population Density
1990
COLUMBIA CO.
WASHINGTON CO.
West Fork Dairy Creek
East Fork Dairy Creek
McKay Creek
Banks
North Plains
Forest Grove
Hillsboro
26
6
47
8
Legend
People per square Mile
< 10
10 to 100
101 to 1000
1001 to 5000
> 5000
Data Sources: US Bureau of Census (1990)
0 1 2 3 4 5
Miles
ECOTRUST


Map 1-6.
Major Land
Ownership
COLUMBIA CO.
WASHINGTON CO.
MULTNOMAH CO.
West Fork Dairy Creek
East Fork Dairy Creek
McKay Creek
Banks
North Plains
Forest Grove
Hillsboro
26
6
47
8
Legend
Owner Type
Private Industrial Forestlands
Private non- Industrial Lands
State Lands
Miscellaneous
BLM Lands
Data source: Oregon State University
0 1 2 3 4 5
Miles
ECOTRUST

1.3.3 Allocations

1.3.3.1 BLM Allocations

1.3.3.1.1 Matrix

Roughly 45% of the BLM land in the Dairy-McKay watershed is allocated within one of two "Matrix" classifications: 1). General Forest Management Allocation (GFMA) or 2). Connectivity/ Diversity. According to the Salem Record of Decision (ROD), the objectives of Matrix lands are to produce timber at sustainable levels, provide habitat for a variety of organisms associated with diverse stands types, maintain stand structural diversity, and provide for organism dispersal. Connectivity blocks have the additional objective of providing connectivity between late successional reserves, and are designed to provide corridor habitat for upland species. Within the watershed, one 520 acre parcel of land (T2N, R3W, S1) is allocated for connectivity (Appendix 4). A minor portion of another connectivity block (T3N, R3W, S13) also falls within watershed boundaries.

1.3.3.1.2 Riparian Reserve

Riparian Reserves constitute 3,166 acres, approximately one-half of all federal lands in the watershed. Riparian Reserves are typically adjacent to streams, ponds, wetlands, and nearby areas of unstable topography. The extent of these reserves varies based on ecological and geomorphic factors. As a rule of thumb, they extend for a width of two site potential tree heights (usually about 400 feet) from each bank of fish-bearing streams. On other streams, the reserves typically extend for 1 site-potential tree (about 200 feet) from each stream bank.

In these reserves, management is centered on preservation of riparian-dependent resources. Other management activities must be conducted in such a manner so as not to conflict with this primary objective. Many species are dependent upon the habitat provided by Riparian Reserves. Additionally, Riparian Reserves assist in maintenance of the aquatic system by providing shade to regulate stream temperature, contributing woody debris to improve structure and diversity of aquatic habitat, and filtering sediments and nutrients supplied by adjacent upland sources.

1.3.3.1.3 Late-Successional Reserve

Late-successional reserves (LSRs) are designed to "protect and enhance the conditions of late-successional and old-growth forest ecosystems" (Salem ROD). These ecosystems provide habitat for many sensitive species, including the spotted owl and the marbled murrelet.

In the Dairy-McKay watershed, one 280-acre block of land has LSR designation. This site, located at Big Canyon (T2N, R3W, S5, South 1/4) has been the focus of past educational and scientific activities.

1.3.3.2 Private Zoning

The Dairy-McKay Creek watershed is in a rapidly urbanizing region of Washington County. In order to restrict urban sprawl and to preserve historical land uses, the Washington County Comprehensive Plan was created. This plan divides the watershed into zones of forestry, agricultural, and urban uses. As now, forestry uses will be centered in the mountainous portions of the watershed, while agriculture will dominate much of the central and lower portions of the watershed. Urban use will expand around the present urban centers in the lower watershed.

Current zoning regulations provide for 48.6% of the watershed in forest use, 31.6% in agricultural use, and 4.5% for urban uses. The vast majority of forest and agricultural lands are zoned for large parcels.

1.3.4 Human Uses

1.3.4.1 Forestry

Forestry is the dominant activity over the northern 50% of the watershed. Of this land, 27,402 acres (38%) is industrial forestland. BLM owns 6,521 acres (9%), and state lands amount to 673 acres (1.6%). Private non-industrial interests own the remaining 53% of forested land in the watershed. Management emphasis varies between these entities, but the vast majority of the land has been harvested within the past 80 years.

In addition to timber harvest, forestry entails related support activities, including fertilization, herbicide application, and road construction. Road density is particularly high in the West Fork of Dairy Creek. However, due to high stream densities, density of road crossings is also very high in the East Fork drainage. In McKay Creek, densities of roads and road crossings are both relatively low, probably because the rugged terrain does not lend itself to road building activities.

1.3.4.2 Agriculture

Agriculture has traditionally been the predominant land use in the Tualatin Valley and continues to be economically important in the Dairy-McKay watershed. Agriculture also carries with it activities that may affect stream water quality. These include tillage, manure storage, fertilization, application of herbicides and pesticides, and encroachment upon the riparian zone. The USDA Natural Resources Conservation Service (NRCS) and Washington County Soil and Water Conservation District (SWCD) work with agricultural land owners to minimize effects of their operations upon streams.

1.3.4.3 Urban

Most urbanized lands in the watershed occur around Council Creek and lower McKay and Dairy creeks. Rapid development continues to occur in these areas. As these subwatersheds urbanize, pressures on water and land resources increase. This gives rise to potential conflicts with aquatic life, agriculture, and other beneficial uses for these resources. These urban reaches also potentially contribute to stream-related problems, such as changed hydrologic conditions and contribution of pollutants through the storm drain system.

1.3.4.4 Recreation

Many recreational activities are supported within the watershed. These include activities that are directly supported by the streams, such as fishing. In the past, upper Dairy and McKay Creeks were known for supporting an excellent cutthroat and steelhead fishery. Other recreational activities supported by natural resources within the watershed are hiking, camping, hunting, birding, bicycling, and touring. Developed recreation is also popular and includes golf and model airplaning. Several developed urban parks exist within the watershed. Most recreational activities in rural lands are found in undeveloped areas, including BLM lands and private timberlands. It has been the policy of some timberland owners, including Longview Fibre, to allow public access to their lands for activities that are consistent with company operations.

Chapter 2: CORE TOPICS AND KEY QUESTIONS

This watershed analysis is designed to provide assistance in addressing diverse issues in the Dairy-McKay watershed. A basic understanding of pertinent physical, biological, and social processes is essential to analysis of more specific questions related to watershed issues. For this purpose, it is useful to use a format of Core Topics and Key Questions. Core Topics are general discussions of processes operating within the watershed. Key questions are specifically designed to address these identified issues of concern. As a quick reference, page numbers are provided to direct the reader to report pages that address each key question.

2.1 AQUATIC

2.11 Erosion issues

Accelerated erosion may exist in some portions of the watershed. Related problems include loss of topsoil, increased stream sedimentation, loss of habitat, and loss of water quality. Under certain conditions, sediment delivery to streams constitutes a "prohibited condition" under SB 1010 and the Oregon Forest Practices Act.

Core topic

What erosion processes are dominant within the Dairy-McKay watershed? Where have they occurred or are they likely to occur? What is the effect of those erosion processes on beneficial uses in the watershed? *See pages: 4, 27-31*

Key questions

- How have human activities affected erosion processes within the watershed? *See pages: 30-31, 81-83*
- Where do prohibited conditions exist? What type of prohibited conditions are prevalent in the watershed? What can be done to eliminate the problem? *See pages: 31, 87*

2.12 Hydrology and water quantity issues

Management activities have modified the natural flow regime in the watershed. Impacts include an altered flooding regime during high water periods, and changes in the amount of water available for human and fish use during low water periods.

Human and instream needs place a heavy demand on water resources. In some areas, water quantity may be insufficient to meet these needs.

Core topic

What are the dominant hydrologic characteristics (e.g. total discharge, peak and minimum flows) and other notable hydrologic features and processes in the watershed? *See pages: 31*

Key questions

- How have human activities altered the natural regime? What are potential effects of the altered flow regime? *See pages: 83*
- Are water rights allocations sufficient to provide both for human and fisheries needs? If not, where are the deficits greatest? Where are the best sites for purchases of water rights for instream purposes? *See pages: 32, 84*

2.13 Stream channel issues

Stream morphology affects the way in which streams transport water and sediments, as well as the stream's ability to provide habitat for aquatic life. Where the channel has been altered through human activity, the ability of the stream to perform these functions will be changed. Furthermore, restoration activities must be appropriate to the natural characteristics of the stream channel.

Core topic

What are the basic stream morphological characteristics and the general sediment transport and deposition processes in the watershed? *See pages: 37*

Key questions

- How have human activities altered stream morphology? In instances where effects have been negative, what sort of restoration activities are appropriate? *See pages: 39, 84, 102, 109*

2.14 Water quality issues

Streams within the Dairy-McKay watershed have experienced diminished water quality relative to reference conditions. Several of these streams have been designated on the ODEQ 303(d) list as having characteristics limiting their ability to support aquatic life and provide recreation. Parameters of concern include high water temperatures, elevated phosphorus levels, and high bacteria counts. Several locations within the watershed have been identified as potential hazardous waste sites under the EPA Superfund program. Local citizens have voiced concern that these sites may provide potentially hazardous impacts to water quality.

Core topic

What and where are the beneficial uses of water in the watershed and which of these are sensitive to activities occurring in the watershed? *See pages: 41, 85*

Key questions

- What beneficial uses of water occur in this watershed? *See pages: 41*
- How is water quality being impacted by management activities and what can be done to reduce these impacts? *See pages: 84, 102, 109*
- What are probable sources of phosphorus in streams? Where do phosphorus levels exceed TMDL standards? What can be done to reduce aquatic phosphorus levels? *See pages: 543, 86, 103*
- What are the factors causing 303(d) listed streams to exceed water quality criteria? What can be done to improve water quality on these streams? *See pages: 86, 102-104*
- At which locations are stream temperatures above desirable levels for salmonid production? What measures can be taken to reduce water temperatures? *See pages: 103-104, 41, 46*
- What is the effect of current water quality upon non-salmonid species? *See pages: 88*
- Where are recreational activities limited by current water quality? What can be done to restore the ability of streams to support recreation? *See pages: 87*
- Where are past and present superfund sites located? What is the current status of these sites? Are they in a position to provide detrimental impacts to water quality? *See pages: 46, 88*

2.15 Aquatic species and habitat issues

Salmonid species are an important component of streams within this watershed. These species are sensitive to changes in aquatic habitat. Upper Willamette steelhead trout are proposed for listing as threatened under the Endangered Species Act. Additionally, coastal cutthroat are a candidate species for listing.

Many species such as frogs, turtles, salamanders and newts are dependent on wetland/marsh and pond areas. It is recognized in the scientific community that frogs are declining worldwide at an unprecedented rate.

Core topic.

- What is the relative abundance and distribution of aquatic and amphibian species that are important in the watershed? *See pages: 48, 50-51*
- What is the distribution and character of their habitats? *See pages: 49, 50-51*

Key questions related to fisheries.

- What factors are impacting habitat quality for fish species of interest? *See pages: 49-50*
- Where are barriers to fish passage located? Of the barriers created through management activity, which would be feasible to alter or remove? *See pages: 50*

Key questions related to amphibian species and wetland habitats.

- Where are marsh/wetland areas and ponds in the watershed? *See pages: 79, 88-89*
- How have human activities impacted these wetland areas? *See pages: 78-79, 89*
- What restoration activities could enhance their historic characteristics? *See pages: 106*
- What is the relative abundance and distribution of wetland-dependent species in the watershed? *See pages: 89*
- What are the population trends for frogs and other species dependent upon moist and aquatic habits? Are there any such species have been extirpated, or face imminent extirpation, within the watershed? What is the prognosis for these species? *See pages: 50-51, 89*

2.2 TERRESTRIAL

2.21 Vegetation issues

The structure and composition of vegetation has been extensively altered from reference conditions. This has altered the type and availability of beneficial uses provided by vegetation. Additionally, these uses have probably favored certain animal species at the expense of others.

Non-native, noxious weed species have colonized many areas within the watershed. These species tend to outcompete native plants, resulting in decreased diversity. Many of these exotic species provide inferior habitat for native wildlife. Additionally, some of these species are poisonous to livestock, and otherwise interfere with agricultural and forest management.

Riparian vegetation has been extensively altered, changing the functions that these areas are able to provide for aquatic and riparian plant and animal species.

Some native plant species are in danger of eradication, are endemic, or are otherwise of special concern. These species include those listed or proposed for listing under the Endangered Species Act (ESA), Survey and Manage Species as identified in the Northwest Forest Plan, and species identified under the BLM Special Status Species Policy.

Core topics

What is the array and landscape pattern of plant communities in the watershed? How does this compare to reference historical patterns? *See pages: 52-53, 75-77, 89-90*

What processes caused this pattern? *See pages: 77-79, 89*

Key questions

- What measures can be taken to retain habitat for terrestrial species and to maintain and enhance forest health? *See pages: 106, 110-112*
- Are ecosystems losing diversity of native species because of the invasion of exotic/ noxious plants? What control measures could be reasonably implemented to reduce the introduction and spread of exotic/noxious plants? What opportunities are available for partnerships in controlling the spread and introduction of exotic plants within the watershed? *See pages: 53, 90, 107, 110*
- [BLM only] What kinds of management practices should be implemented in the Riparian Reserves to enhance their function? *See pages: 111*

2.22 Species and habitat issues

Some terrestrial animal species bear special concern because of diminished numbers or endemic status. Care must be taken to avoid further reduction in numbers of these species. These include species listed or proposed for listing under the Endangered Species Act (ESA), Survey and Manage Species as identified in the Northwest Forest Plan, and species identified under the BLM Special Status Species Policy.

Some species are popular as game. It is important to maintain these species at a sustainable level.

Core topic

What is the relative abundance and distribution of terrestrial species of concern that are important in the watershed? What is the distribution and character of their habitats? Are there any known sites in this watershed for these species? *See pages: 54-61*

Key questions

- Which species are listed or proposed for listing under the Endangered Species Act, identified in the Northwest Forest Plan as Survey and Manage Species, or have status under the Bureau's Special Status Species Policy? What are their relative abundance and distribution? *See pages: 57-61, 91*
- What are the condition, distribution and trend of habitats required by those species of concern that may occur in the watershed? *See pages: 57-61*
- What are the current distribution and density of snags and down wood on lands within the watershed? *See pages: 61*
- What are the natural and human causes of change between historical and current species distribution and habitat quality for species of concern in the watershed? *See pages:* 76-78, 91
- What are the influences and relationships of species and their habitats with other ecosystem processes in the watersheds? *See pages: (dispersed throughout document)*
- What are the major contributing factors leading to the decline in population levels for those species which are of concern? How does the ownership pattern affect habitat potential and management opportunities, and the potential for quality habitat within the watersheds? *See pages: 57-61, 91*

2.23 Forest resources issues [BLM only]

Key questions

- What stand management practices should be considered to enhance wood production and quality, and reduce losses from laminated root rot and other forest pathogens in the watershed? *See pages: 112 (Phellinus), 111 (Douglas-fir beetles)*
- What stand management practices should be considered in the management of hardwood stands in the watershed? *See pages: 111, 112*
- How can late-successional old-growth goals best be reached in Late Successional Reserves and Riparian Reserves? *See pages: 110*
- What criteria should be used to determine when and where harvest will take place on GFMA and connectivity land? *See pages: 113*

2.3 SOCIAL

2.31 Issues related to human uses

Important economic and recreational activities take place in the watershed. These activities make demands upon watershed resources and provide potential conflicts with other watershed interests. BLM lands are typically in small parcels scattered through the northern portion of the watershed. Potential conflicts exist between BLM activities and the activities of other rural landowner/ users. Dumping takes place on unoccupied forest lands.

Core topic

What are the major human uses and where do they occur in the watershed? What demands are changing land uses placing upon the watershed? *See pages: 19-20, 62-66, 93-96*

Key questions

- Is dumping a large enough problem that the BLM and other land owners/managers should pursue special, more intense, abatement efforts? *See pages: 66, 113*
- Is there a conflict between the public and BLM management practices, and what can be done to prevent possible conflicting situations? *See pages: 66, 113-114*
- What are current recreational opportunities in the watershed? What demands do they place on resources? Can these demands be reduced? Are there opportunities to encourage low-demand activities? *See pages: 66, 114*

2.32 Road-related issues

Roads can contribute to hydrologic change, erosion, and mass wasting. Road-related ditches tend to concentrate flow, facilitating ditch erosion and transport of eroded sediments from the road. In certain cases, roads may contribute to excessive sediment delivery to streams, affecting fish habitat. Stream crossings usually necessitate placement of culverts. Poorly placed culverts can alter channel morphology, increase stream density, and impede fish passage. Undersized culverts can wash out during flooding events.

Hazards are not limited to currently maintained roads, but also extend to so-called "legacy roads". These discontinued roads railroad grades, and associated culverts, can impede fish passage.

Restricted access to certain BLM lands limits management opportunities. In many cases, physical constraints or lack of legal access have prevented road construction. In other cases, roads exist, but have been closed by slope failures.

Key questions

- Where are high risk areas for slope failures due to roads? What resources are potentially at risk as a result of road failures within these areas? What criteria should be used to determine the feasibility of road closures? *See pages: 68, 99, 108, 114-116*
- What is the overall road density, and the density in each subwatershed, for BLM roads and roads of other ownership? *See pages: 68*
- How many stream crossings, bridges, and culverts are in the watershed? Which of these structures impede fish passage? *See pages: 70*
- What is the size and condition of existing culverts? Are they likely to withstand a 100 year flood event? *See pages: 70*
- Where are rock pits and other sediment sources located? What measures should be taken to mitigate for impacts of these sites? What funding sources are available for mitigation? *See pages: 95, 96*
- [BLM only] Which BLM-owned parcels lack road access? What factors limit access to these lands? *See pages: 70*
- [BLM only] What roads should be closed to entry by blocking, obliterating, or decommissioning? Which of the three methods is preferable to use to close these roads? *See pages: 114-115*
- Where are potential trouble spots related to discontinued roads and railroad grades? What opportunities exist for mitigation of impacts related to these roadfs? *See pages: 96*

Chapter 3: Current Conditions

3.1 AQUATIC

3.1.1 Erosion processes

3.1.1.1 Overview of erosion and sedimentation processes

There are two major subdivisions of the Dairy-McKay watershed in terms of erosion and sedimentation processes. The Tualatin Mountains comprises the area falling into the Willapa Hills and Volcanics ecoregions, while the Tualatin Plain is analogous to the Prairie Terraces ecoregion. Between the two is a transitional region, termed the Valley Foothills.

Much of the mountainous portion of the watershed is characterized by relatively steep terrain and deeply incised canyons. In regions capped by Columbia River basalt, headwater reaches of the stream courses often have gentler gradients than the reaches immediately downstream. Steep slopes and weak lithologic materials render these mountainous areas susceptible to mass wasting and other erosion processes. The upper portions of Dairy Creek are typically underlain by Tertiary marine sedimentary formations, which are typically fine-grained siltstones with low permeability. Some sandstones also exist in this formation. Much of the rest of the mountainous portion of the watershed, including the headwaters of McKay Creek, is underlain by Columbia River basalt. Both the sedimentary and basalt formations tend to degrade into fine-grained particles. Erosion in these mountainous portions is typically dominated by mass wasting processes, including shallow landslides, slumps and mudflows (BLM 1979). Under natural conditions, extensive surface erosion would not occur. However, where large areas of mineral soil have been stripped of their vegetative cover, surface erosion can be significant.

The fine-grained particles produced from erosion in the incised middle to upper-middle portions of the mountains are often delivered to streams. This is an especially important process in first and second-order reaches, where steep canyon walls often expedite the delivery of eroded material to the streams.

In the valley, slopes are generally low. Where soils are exposed to rainfall energy, they are readily detached. However, the ability to transport eroded soils to stream systems is limited. Where erosion takes place far from stream channels, eroded soils are usually redeposited prior to delivery to the streams. Localized erosion and delivery to streams occurs on both terraces and streambanks.

3.1.1.2 Mass wasting

Mass wasting (landsliding and related processes) provides substantial sediment inputs to the stream system. In many cases, slides are confined to small, shallow, debris slides from canyon walls into first and second order streams. This type of sliding has been identified as the most common landslides on steep, forested, slopes in Western Oregon (Dent et al. 1998). However, large, rotational slumps are also important within the watershed. There are several indicators for determining risk of mass wasting.

The greatest single indicator of landslide susceptibility is slope. The vast majority of landslides occur on slopes of greater than 70%. Due to map generalization, such slopes are commonly found in areas expressed as 60% slope or greater on a USGS 7.5-minute quad. These areas can be considered to have high landslide susceptibility. Areas with slopes ranging from 30% to 60% are considered to have moderate landslide susceptibility, while mass wasting potential is low where slope does not exceed 30%. (Dave Michael, ODF, Personal communication).

Topographic maps and GIS layers are often useful for performing a preliminary screening of risk of slope failure. However, it should be noted that decisions should not be made using these tools alone. Due to generalization, maps are typically insensitive to local changes in topography. GIS slope layers often share this insensitivity, and in many cases have errors in the source data. The results of this slope analysis are to be taken as general indicators of landslide susceptibility and are not to be used for site-specific assessments.

Figure 3-1 shows areas in the watershed falling into the various slope classes. Slopes exceeding 30% are common throughout the Tualatin Mountains. Almost 20% of the Dairy-McKay watershed falls within this slope class. Inner gorges of streams, in particular, are likely to fall within this slope class. Less than one percent of the watershed exceeds the 60% slope criterion. Most such slopes are found along the inner gorges of the middle portion of the McKay Creek watershed, including McKay Creek, Neil Creek, and the East Fork of McKay.

Lithology also has a role in determining mass wasting susceptibility. The sedimentary formations are quite weak and susceptible to sliding. When unweathered, Columbia River basalt is considered to be quite resistant to mass wasting and erosion (Schlicker 1967). However, much of the basalt within the watershed is deeply weathered (Hart and Newcomb 1965)[1]. Where decomposed basalt formations exist, mass wasting plays a significant role. This is particularly true in the middle reaches of the McKay Creek watershed, particularly in the middle reaches, where slopes are deeply incised in siltstone and basalt formation. Field examinations have shown a lot of past and present landsliding activity in this region.

A particularly notable landslide in the Middle McKay-East Fork subwatershed (T2N, R2W, S18, SW1/4) has closed Dixie Mountain Road since 1996. This slide is associated with nearby quarrying operations. There are continued concerns that this slide may present a sediment hazard to McKay Creek.

Large landslides are also associated with the sedimentary formations. Several slumps are apparent above Williams Creek, in the West Fork Dairy Creek drainage (T3N, R4W, S28, SW1/4, and S33, Nw 1/4). These slumps developed during heavy precipitation events in 1995.

Many landslides continue to be associated with roads. However, while examining Oregon sites of slides associated with the 1996 flood, ODF (1998) found that the proportion of road-related slides relative to other slides had decreased from numbers quoted in past reports. This decrease was attributed to improved road-building techniques.

3.1.1.3 Surface and streambank erosion

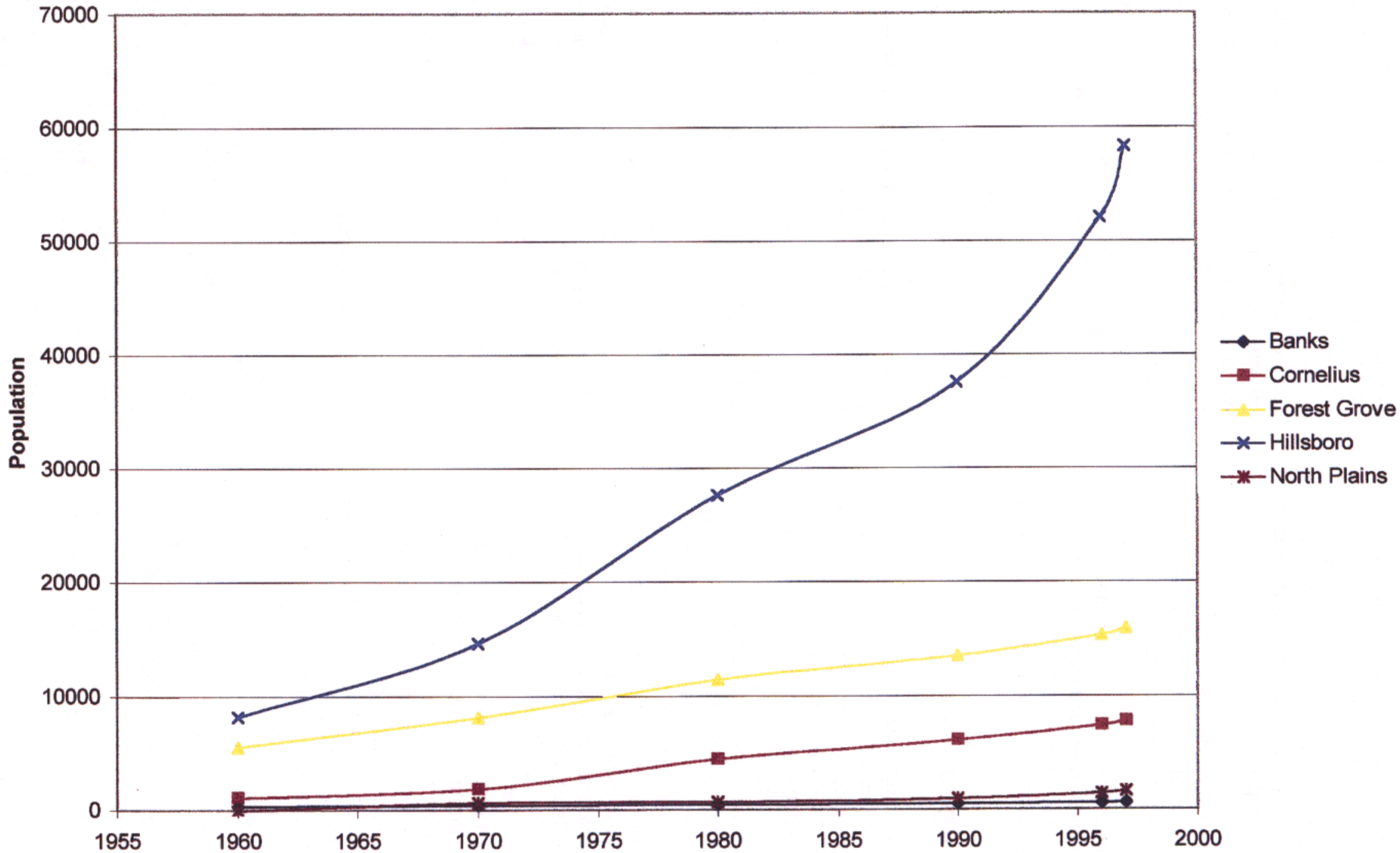
In the Tualatin Mountains, the underlying lithology strongly affects the erodibility of the soils. The weak siltstone formations of the upper reaches of Dairy Creek readily erode into fine-textured particles. Likewise, the ultisols formed from the Columbia River basalt are also quite susceptible to surface erosion.

Where adequate vegetative cover exists, surface erosion is a minor concern in mountainous portions of the Dairy-McKay watershed. However, where soil exposure and compaction occurs, surface erosion can become an important factor. In these cases, slope, climate, lithology and soil erodibility affect the relative magnitude of surface erosion. The most significant anthropogenic source of accelerated surface erosion is due to road building activities, although sheet, rill, and gully erosion can be important after a site is logged and before new growth provides adequate ground cover.

Valley portions of the watershed are underlain by alluvium of Tertiary and Quaternary ages. Erosion within such areas is through streambank, sheet, rill and gully processes.

[1]Schlicker (1967) downplays the role of insitu weathering for these weathered lateritic layers. Instead, he ventures the opinion that most of these laterites were deposited through sedimentary processes.

Figure 3-1. Population of Cities within the Dairy Creek Watershed, 1960-1997



Streambank erosion occurs throughout the watershed, but is most significant along higher order streams that are not confined by valley walls. Although streambank erosion occurs under natural conditions, the magnitude of erosion has been increased due to altered hydrology, channelization and destruction of riparian vegetation. Streambank erosion due to vegetation damage by livestock also occurs, but is probably minor compared to erosion caused by the other anthropogenic factors.

Dairy and McKay have developed natural levees along the lower, meandering portions of their courses. During flooding events, sediment is deposited, resulting in increased elevation of streambanks. In many places, during peak flow, the stream water is higher in elevation than the surrounding floodplain. These streams often overtop the bank and flow into the floodplain. Where this occurs, the hydraulic energy of the floodwaters erodes the streambank and portions of the nearby floodplain.

Such erosion is a part of the natural stream meandering process. This process is restricted, however, by landowners who repair the breaches in the streambank, by bridges (which form hard barriers containing the channel), and by streambank protection projects. The result is that a system of artificial, resistant, levees has developed along many reaches of streams.

Sheet, rill, and gully erosion in the valley portion of the watershed, however, probably pose more important threats to water quality and agriculture than does streambank erosion. While streambank erosion erodes throughout the soil profile, the topsoil layers eroded through sheet, rill, and gully processes are the most likely to be enriched in nutrients and pollutants. Although no estimates have been made of relative amounts, sheet, rill, and gully erosion is more likely than streambank erosion to carry nutrients, bacteria, organic matter, and pesticides into the stream. Also, topsoil losses due to sheet, rill, and gully erosion represent a more significant resource loss to agriculture than does soil loss from streambank erosion.

Soils classified as "Highly Erodible Land" by NRCS have steep slopes and are mostly located on hillsides that form a transition area between the mountainous areas and the valley. Rolling lands in valley landscapes, however, are also prone to sheet, rill, and gully erosion.

3.1.1.4 Human impacts on erosion processes and sediment production

There is considerable evidence that human activities have altered the erosional characteristics of the watershed. In general, these changes tend to accelerate erosion. However, specific efforts have been made to implement policies that reduce erosion. In the Tualatin Mountains, the greatest changes to erosion characteristics have been caused by forestry and road-building operations. In the Tualatin Plain, agriculture has had the greatest influence upon erosion patterns.

Forestry practices affect the amount of soil eroded from hillslopes. Typically, slopes are greater in forested regions, leading to increased erosion potential. Factors leading to increased erosion include reduced vegetation, road construction, soil disturbance due to skidding and other management activities. Where inadequate vegetative buffers exist increased sediment delivery to channels can result. Additionally, unsound forest practices on unstable soils can lead to accelerated mass wasting.

Historically, forestry practices accelerated mass-wasting and surface erosion. Two such practices included tractor-yarding, which disturbed the soil layer, and harvest of riparian zones, which reduced bank stability and increased sediment delivery to streams. Recent improvements in the Oregon Forest Practices Act have diminished the impact of forest activities upon erosion and stream sedimentation. However, the effects of past practices, including stream aggradation, may still be in effect in downstream portions of the watershed.

Field trips and spot analysis of aerial photography found no clear evidence of recent large-scale erosion or mass-wasting caused by forest management. Two of the large slumps on Williams Creek were immediately below large clearcuts. However, it was not immediately clear whether forest management was involved, nor in one of the cases whether the cut antedated the landslide.

In the past, roads have been identified as the primary contributor to sedimentation from forested lands. Both roads related to timber harvest and other roads have had associated erosion and sedimentation problems. Further examination of the role of roads is given in Section 3.3.2.

Next to roads, vegetation management probably has the greatest impact upon erosion and sedimentation. This impact is most evident on steep slopes, unstable soils, and in riparian zones. Tree removal typically has an erosional impact for 5 years following harvest. In the Dairy-McKay watershed, an estimated annual erosion of 137,000 tons a year is associated with timber harvest (SCS 1990 as cited in Wolf 1992).

Increased water yield from forest harvest can lead to increased high flows, which in turn can contribute to increased streambank erosion where insufficient riparian vegetation exists to provide streambank protection (Wolf 1992). These increased high flows are usually of concern in areas subject to Rain-on-Snow (ROS) precipitation. Rainfall dominated areas, such as the Dairy-McKay watershed typically do not incur massive changes in flood peaks due to harvest. Also, surface erosion is not usually greatly accelerated, provided that the forest soil layer is not greatly compacted and that the duff layer is preserved (Wolf 1992, Washington State Forest Practices Commission 1997).

Agriculture is potentially a major contributor to erosion and stream sedimentation. Agricultural practices that tend to promote surface erosion include activities that loosen the soil and reduce vegetative surface cover. Where such activities occur near an inadequately buffered stream channel, the risk of sediment delivery to the stream is increased. The situation is made worse when agricultural activities reduce the vegetative buffer in the riparian zone. In such cases, the potential for streambank erosion and sediment delivery to streams is increased. Evidence exists that agricultural operations have resulted in accelerated streambank erosion in the Dairy-McKay watershed. In many valley locations, stream buffers are poorly vegetated. Buffers are particularly poor along reaches of the West Fork of Dairy Creek, on virtually all channelized reaches, such as Council Creek and lower Bledsoe and Jackson creeks, and on tributaries with source waters within the valley portion of the watershed. Stream surveys in the early 1990's found the majority of streambanks to be actively eroding. The worst erosion was noted in surveyed reaches in agricultural areas (Ward 1995). On Dairy Creek between Roy Road and the railroad bridge south of Highway 26, USA (1995) found that 100% of the surveyed streambank was eroding. In another survey cited by NRCS (1998), six miles of streambank within the Dairy-McKay Creek Hydrologic Unit Area were identified as needing stabilization.

In recent years, many agricultural operations have implemented practices that reduce erosion and sediment delivery to Dairy Creek and its tributaries. Partnerships with governmental conservation agencies have been instrumental in this process. For example, the Natural Resources Conservation Service (NRCS), Washington County Soil and Water Conservation District (SWCD), and the Farm Services Agency have worked with farmers to reduce erosion and improve water quality. Methods have included programs to share costs with farmers for implementation of erosion-reduction techniques, incentives to remove riparian lands from agricultural production, educational efforts, provision of technical assistance, implementation of conservation plans, and restoration projects. These programs have found extensive application within the watershed. Between 1994 and 1998, resource management plans were developed for 30,344 acres of agricultural land in the Dairy-McKay watershed. Of the six miles of streambank identified as needing stabilization, 4,495 feet of streambank have been improved (NRCS 1998). Between 1991 and 1995, conservation practices administered through these agencies had reduced soil loss by an estimated 95,000 tons. Estimated reductions in sediment delivery in agricultural areas was estimated at 8,624 tons annually (NRCS 1998). Although substantial reductions in erosion and sediment delivery have been effected, lack of staffing has prevented these agencies from achieving the full benefit that could be achieved through these programs.

3.1.1.5 Prohibited conditions

Under the Tualatin River Subbasin Agricultural Water Quality Management Area Plan, certain conditions potentially resulting from landowner management activities were specifically prohibited (Appendix 3). Such prohibited conditions include excessive sheet and rill erosion, excessive gully erosion, lack of ground cover in riparian areas, summer discharge of irrigation water to streams, and placement of wastes where they would be likely to enter streams. An effort is currently underway to evaluate the existence and extent of these prohibited conditions. (Also see section 5.1.4.6.)

Landowners have the option of developing a Voluntary Water Quality Farm Plan in conjunction with the SWCD, delineating an approach to protect water quality on their land. If such a plan is not adopted and a prohibited condition occurs, the Oregon Department of Agriculture (ODA) can take enforcement actions.

3.1.2 Hydrology and water quantity

3.1.2.1 Hydrologic characteristics

The precipitation regime of the Dairy-McKay watershed is rainfall dominated. Snowfall is not a major source of precipitation. Most of this rain falls between November and March (Figure 1.1). In general, precipitation intensity is low relative to intensities in the western watersheds of the Tualatin Basin. The 25-year, 24-hour precipitation for this area ranges from 3 to 6 inches, with most of the watershed falling within the 3 to 4 inch category. This contrasts with the western tributaries of the Tualatin River, where this precipitation parameter ranges as high as 14 inches (OCS 1997).

Due to the lack of storage as snow and groundwater, discharge is seasonal and largely follows the precipitation cycle. Flows are very high in winter and achieve very low levels between July and October. Although these summer flows get quite low, most streams within the watershed are perennial. Only the smallest streams dry up in the summer.

A number of springs are present in the mountainous portions of the watershed. These are largely found in the sides of ravines in basalt formations. Some of these springs produce up to 100 gallons per minute (gpm) (Hart and Newcomb 1965). Many of these springs are concentrated in hills surrounding West Fork Dairy Creek. Large springs include Shipley Springs (T2N, R3W, S19, SW1/4) and Normandin Spring (T1N, R4W, S8, NE1/4)

In the Dairy-McKay watershed, continuous monitoring and long-term discharge records are scarce. A gage exists on Lower Dairy Creek at Highway 8, but historically has only been operated during low-flow months. Another gage, on Lower McKay at Hornecker Road, was installed in 1992 by USA as part of the instream monitoring program. Two other staff gages, East Fork Dairy Creek at Mountaindale, and McKay Creek at North Plains also were maintained in the 1950's. Comparability of gage statistics is questionable as periods of record vary between the gages.

During the 1990s, the recorded annual low flow on McKay Creek at Hornecker Road varied from 0.87 cubic feet per second (cfs) to 1.47 cfs (Appendix 2). Over the same time period, annual minimum flow at "Dairy Creek at Highway 8" varied from 3.3 cfs (5.5 cfs) to 31.5 cfs. The 3.3 cfs figure is abnormally low relative to the readings surrounding it, and may represent measurement error, or the effects of abnormally heavy diversions. Dates of the annual low flow for these streams varied between July 24 and October 14. In most years, the annual low flow took place in September.

Athough Dairy Creek lacks year-round flow measurements, the Oregon Water Rights Department (OWRD) has modeled flows for Dairy Creek at its mouth. The modeled monthly 50% and 80% exceedance streamflows are given in Appendix 2. Based on this model, Dairy Creek has a median monthly September low flow of 31 cfs at its mouth. In contrast, the highest flows occur in February, with a monthly median flow of 848 cfs.

Streamflow was measured on the East Fork Dairy Creek near Mountaindale between 1941 and 1951. During this time period, mean monthly discharge at this station varied from 13 cfs in August and September to 306 cfs in February. The minimum flow recorded was 7 cfs in September 1944. The maximum flow was 1,420 cfs on February 17, 1949. Drainage area at this location is 43.0 square miles.

Discharge was measured on McKay Creek near North Plains between 1941 and 1956. Over this period, mean monthly discharge varied from a low of 3 cfs in August and September, to a high of 198 cfs in February. The minimum flow recorded at this site was 0.4 cfs in August, 1951. Maximum recorded discharge was 2,100 cfs on February 17, 1949. Drainage area at this location was 27.6 square miles.

3.1.2.2 Water quantity and water rights

Lack of summer streamflow is an important concern within the Dairy-McKay watershed. In summer, the flows get very low, indicating a vulnerability to diversion. Additionally, natural drought cycles lead to a decreased natural pool of available water. Decreased stream volume can have adverse impacts, both to instream life and to human uses. These impacts include adverse changes to water temperature, decreased pool depth, decreased dissolved oxygen, and other detrimental impacts on aquatic life. Inadequate streamflow also leads to decreased availability to human uses, and can lead to aesthetically unpleasant water. In response to this problem, the Oregon Water Resources Department (OWRD) has decided that no additional water rights allocations are available within the basin during the months May to November. Portions of the basin have no available allocations throughout the year.

Table 3-1 shows the magnitude, by subwatershed of permitted water rights for direct diversion from streams within the Dairy-McKay watershed. The heaviest diversions from streams occurs in the lower portion of the watershed. In particular, Dairy Creek, West Fork Dairy Creek below Banks and the East Fork Dairy Creek below Murtagh Creek have almost 65% of permitted potential diversion.

Irrigation is the largest single water use within the watershed (Table 3-2). Of 177.9 cfs in total allocated

Table 3 1. Total surface water rights by subwatershed

Subwatershed	# of rights	Total allocated cfs.
Bledsoe Creek	18	2.925
Brunswick Canyon	3	0.300
Burgholzer Creek	5	0.890
Cedar Canyon	40	24.853
Council Creek	6	2.375
Dairy Creek	49	21.650
Denny Creek	6	3.665
East Fork Dairy Creek	52	26.487
East Fork McKay Creek	4	0.115
Evers Reservoir	46	17.817
Garrigus Creek	9	1.557
Gumm Creek	48	15.822
Jackson Creek	8	0.880
Kuder Creek	11	1.485
Lousignont Canal	29	11.733
Lower McKay Creek	21	5.094
McKay Creek	18	5.518
McKay-Tualatin Confluence	20	8.126
Mendenhall Creek	9	0.951
Middle McKay Creek	27	8.483
Middle West Fork Dairy Creek	28	7.370
Murtagh Creek	10	0.277
Neil Creek	4	0.810
North Hillsboro	2	0.145
Panther Creek	4	0.170
Park Farms Creek	5	0.595
Plentywater Creek	11	1.325
Sadd Creek	9	0.745
Storey Creek	3	0.465
Upper Waibel Creek	4	0.490
Upper West Fork Dairy Creek	7	0.394
Waibel Creek	1	0.875
West Fork Dairy Creek	13	2.684
Whitcher Creek	10	0.835

instream diversions, 164.0 cfs, or 92%, was allocated to agricultural needs. Given that the majority of these rights are effective during the summer low-flow season, this indicates a tremendous potential over-allocation of available water. However, demands are reduced upon this water supply because many farmers with rights to Dairy Creek water also have water rights from the Tualatin Valley Irrigation District (TVID) (D. Hedin, OWRD, personal communication).

Agricultural water rights usually have a maximum cumulative annual withdrawal of 2.5 acre-feet per acre of irrigated land. However, this maximum is not typically fully utilized. In 1987, annual irrigation demand from the Washington County Water Resources Management Plan was estimated at 27,532 acre-feet distributed over 25,491 acres, or 1.08 acre-feet per acre (that is, a mean depth of 13 inches). A more recent study indicates that TVID provided 0.9 acre-feet of water for every acre that it serviced (Montgomery Watson 1998).

In 1956, about 18 inches of irrigation water per growing season was considered necessary for optimal growth (Hart and Newcomb 1965). However, only about two-thirds of this total was available at the time, resulting in suboptimal irrigation for growth. Based on current irrigation figures, it appears that actual water use per acre of land has not changed appreciably since the 1950s. However, it is likely that modern farms are deriving more productivity per acre-foot of water. Some additional benefit could be attained by implementing Best Management Practices designed for water conservation.

Under Oregon law, conflicts over water rights are resolved under the doctrine of prior appropriation. In effect, water rights obtained first have first priority to available water. For this purpose, each water right permit is assigned a priority date, which is usually the date of the application for the permit. Water rights with earlier dates, thus higher priority, are termed "senior water rights".

On Dairy Creek and several tributary streams, water rights have also been assigned for instream uses. These rights are granted to promote sustenance of fish and wildlife. A list of minimum instream water rights is given in Table 3-3. East Fork Dairy Creek has the greatest instream rights, with a right ranging from 12 cfs from mid July to mid November, to 50 cfs from mid-November to May. These latter flows are increased to allow for spawning and migration of salmon and steelhead. Instream water rights in the other tributaries typically range from 1 to 2 cfs in low-flow season, and increase to 20 to 36 cfs during salmonid migration and spawning. The priority date for Dairy Creek at the Tualatin River is set at August 3, 1993, while instream rights for the West Fork Dairy Creek have a priority date of November 3, 1983. Priority date for all other instream water rights in the watershed is set at May 25, 1966. Water rights holders with priority dates earlier than this date would have priority over these instream rights. As there are a large number of senior rights in the watershed, the instream water rights frequently lose regulatory protection from OWRD. In 1998, a relatively wet water year, instream water rights in lower Dairy Creek and West Fork Dairy Creek were ineffective after July 31. However, this loss did not cause streamflow on Dairy Creek to fall below levels specified by the instream rights. The older instream water rights remained in effect throughout the summer. Many of the more recent water rights permits restrict withdrawals between November and March, with the purpose of ensuring adequate water remains instream for salmonids.

Through its instream leasing program, OWRD offers incentives for water rights holders to lease their rights for instream uses. This program is particularly useful for rights holders who are temporarily do not expect to use their full allocation of water. The holder's water rights are protected throughout the period of the lease. Minimum lease period is two years.

Between 1997 and 2050, municipal and domestic water needs in Washington County are expected to grow by 94%, with an anticipated increase in "peak day demand" of 131%. In 2050, peak daily demand was expected to exceed the present capacity of Washington County to provide water for these needs (Montgomery Watson 1998). Early studies indicate that this capacity could be exceeded by 2010 (WAMCO 1989).

3.1.2.3 Flooding

Flooding is another important concern within the watershed. Although flooding is a natural part of the stream regime, it conflicts with extensive agricultural and urban development within the floodplain. Flooding is largely a function of watershed topography. ODEQ and USA (1982) noted that flows from headwater reaches tended to synchronize with downstream runoff, creating periods of extended flooding. Additionally, many portions of the basin are underlain by poorly-drained alluvial silts. A large area of poorly drained soils is located northeast of David Hill, in the West Fork Dairy Creek drainage.

Extensive portions of the watershed lie within the 100-year floodplain (Map 3-2). This indicates that such a major flood could have enormous effects upon urban

Table 3.2. Total surface water rights by type of use.

USE		number of water rights	Average (cfs)	Cumulative (cfs)	% of total
AS	Aesthetic	1	0.020	0.0200	0.01%
DB	Dairy Barn	2	0.010	0.0200	0.01%
DI	Domestic	7	0.011	0.0800	0.04%
DN	Domestic	1	0.010	0.0100	0.01%
DO	Domestic	23	0.037	0.8500	0.48%
DS	Domestic/stock	13	0.215	2.8000	1.57%
FI	Fish	11	0.069	0.7600	0.43%
FP	Fire protection	5	0.014	0.0700	0.04%
ID	Irrigation and Domestic	3	0.057	0.1700	0.10%
IM	Manufacturing	4	0.500	2.0000	1.12%
IR	Irrigation	430	0.381	163.9685	92.17%
IS	Supplemental Irrigation	13	17.405	3.4650	1.95%
LV	Livestock	6	0.005	0.0270	0.02%
MU	Municipal	2	0.090	0.1800	0.10%
NU	Nursery Use	4	0.530	2.1200	1.19%
RC	Recreation	11	0.104	1.1450	0.64%
ST	Storage	2	0.050	0.1000	0.06%
WI	Wildlife	3	0.040	0.1200	0.07%
	Total	541	20	178	100.00%

and agricultural areas of the watershed. One such test occurred in 1996. During this event, the most extensive flooding occurred along Dairy Creek and its two main forks. The West Fork, in particular, was hard hit.

Another consideration is that retention of water in the Dairy Creek floodplains has helped to moderate flood peaks downstream on the Tualatin River. Despite channelization of many stream reaches within the watershed, the watershed appears to retain much of this function (ODEQ and USA 1982).

3.1.2.4 Groundwater

Both confined and unconfined aquifers provide important sources of groundwater in the Dairy-McKay watershed. The best confined aquifers are found in the Columbia River basalt. Wells tapping this aquifer sometimes produce at several hundred gallons per minute. Several large agricultural operations, and the City of North Plains tap into this aquifer. However, this aquifer has a limited storage capacity, and in areas of heavy usage, withdrawal can exceed recharge.

Such depletion has occurred in other parts of the Willamette Valley, including the Cooper Mountain area of the Tualatin Basin. Such areas have received official designation as critical groundwater areas and groundwater limited areas, with accompanying restrictions to usage. Although no parts of the Dairy-McKay watershed currently suffer such depletion, it can be anticipated that such designations would become necessary in the future if withdrawals consistently exceeded recharge.

The sedimentary formations typically produce low yields of water, and are not considered good aquifers. Such aquifers are found in the upper portions of the West Fork and, to a lesser degree, the East Fork Dairy Creek drainage.

Unconfined aquifers are an important source of groundwater within the valley plain. Most of this water is found in lenses of coarse sand and fine gravel within the relatively impermeable valley silts. Some of these lenses are found in the Hillsboro-Forest Grove corridor. Although these lenses do not produce as well at any one given site as do the wells within the Columbia River basalt, they are the most important source of groundwater within this corridor. The City of Hillsboro, for example, taps into this aquifer (Hart and Newcomb 1965).

Seasonally high recharge can lead to circumstances where the water table rises to the surface, particularly in December and January. At these times, seasonal wetlands become flooded. Such wetlands are found in the West Fork Dairy Creek drainage near Verboort. In addition to shallow water tables, soil impermeability contributes to this situation.

Table 3-3. Minimum perennial streamflows (cfs) as regulated by instream water rights in the Dairy-McKay watershed.
Priority for all water rights is May 25,1966, except for Dairy Creek (8/5/93) and West Fork Dairy Creek (11/3/83).
(Source, Darrell Hedin, Tualatin Watermaster District 18).

		OCT	NOV	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	JUL	AUG	SEP
Stream Name	Above		1-15	16-30								1-15	16-30		
Dairy Creek	RM 2.06	10	10	10	10	10	10	10	10	10	10	10	10	10	10
WF Dairy Creek	RM 7.7	4 (10)	30	30	30	30	30	30	30	30	10 (6)	3	2	2	2
EF Dairy Creek	RM 12.5	12	12	50	50	50	50	50	50	50	25	25	12	12	12
Denny Creek	Mouth	2	2	15	15	15	15	15	15	15	3	3	3	2	2
Plentywater Cr.	Mouth	1	1	5	5	5	5	5	5	5	2	2	2	1	1
McKay Creek	RM 15.5			36	36	36	36	36	36	36				4	4
EF McKay Cr.	RM 0.5													2	2

3.1.2.5 Human impacts on hydrology

The natural flow regime has been altered through several anthropogenic influences. These include:

Channelization. Many tributary streams in lower portions of the watershed have undergone extensive channelization for drainage and flood control. The most notable examples are in the western part of the watershed, where Lousignont canal and other canals cut through former wetlands. Bledsoe and Bausch Creeks in the East Fork Drainage, and Jackson Creek in the McKay drainage, are other examples. As a conservative estimate, 50 stream miles have been channelized[2]. Potential effects of channelization include hydrologic separation of the stream from its floodplain, reduced water detention, and increased downstream flooding. Stream cleaning and straightening associated with channelization reduce resistance to flow and locally increase the stream gradient, resulting in increased velocity and erosion. Additionally, channel straightening tends to destroy riparian vegetation, and reduces the length and diversity of instream and riparian habitats.

Diversions. As discussed earlier in this section, water diversions are distributed throughout the valley portion of the watershed. Impacts of these diversions include reduced streamflow, which in turn leads to increased summer water temperatures and decreased instream habitat for aquatic life. Where these diversions are unscreened, they also pose a hazard to fish populations by diverting them onto agricultural fields.

Vegetation changes. Removal of vegetation and large wood from channels reduces resistance to flow, thus increasing the velocity of stream discharge. Although this has the potential benefit of reducing local flooding, it increases the prospect of downstream flooding, reduces available habitat, and increases erosion.

Impervious surfaces. Urbanization has increased the amount of impervious surface, particularly in lower portions of the watershed. This results in quicker runoff to the stream, decreased infiltration, lower water tables, and increased inputs of pollutants to aquatic systems.

Drainage. Agricultural and urbanized areas in valley landscapes throughout the watershed has largely been drained by surface and subsurface ("tile") drains. This has increased peak winter flows and decreased summer flows in Dairy Creek, McKay Creek, and the Tualatin River.

3.1.3 Stream channel

3.1.3.1 Stream morphology and sediment transport processes

Major stream channels in the watershed were typed according to size, gradient, and confinement characteristics (Map 3-3)[3]. In order to characterize *the channel structure within the watershed, a channel* typing methodology patterned after the Governor's Watershed Enhancement Board (GWEB) approach was employed (NPS 1997). This approach offered the advantage that the assessment could be performed rapidly using topographic maps, as contrasted with other methods that require more intensive field work. Office-based channel typing using the GWEB methodology is useful for rapid stratification of watershed stream reaches for characterization and preliminary planning. However, field study should precede any site-specific project planning. Additionally, ongoing changes to the GWEB methodology are expected to result to further modifications to the stream types shown in Map 3-3. A list and descripon of GWEB channel types is given in Appendix 5.

Limited ground-truthing was performed, and reports analyzed, to determine the character of channels within the watershed. The analysis revealed recurring stream characteristics.

Most streams in the watershed have "moderate gradient headwater channels" (GWEB MH classification). These channel types, which are common within Columbia River basalt formations are hillslope constrained, but do not offer the steep gradients typical of headwater reaches in many mountainous regions (NPS 1997). Although they are sediment source regions, their form is less conducive to sediment supply than steep type headwater channels. In the Dairy-McKay watershed, this channel type has a variety of potential substrates. In some locations, cobbles or larger substrates are dominant. However, many of the first order streams of this channel type have substantial inputs of fine, colluvial sediments.

Downstream of the headwater reaches, most streams become "moderately steep, narrow valley channels" (GWEB type MV). Although they are loosely termed

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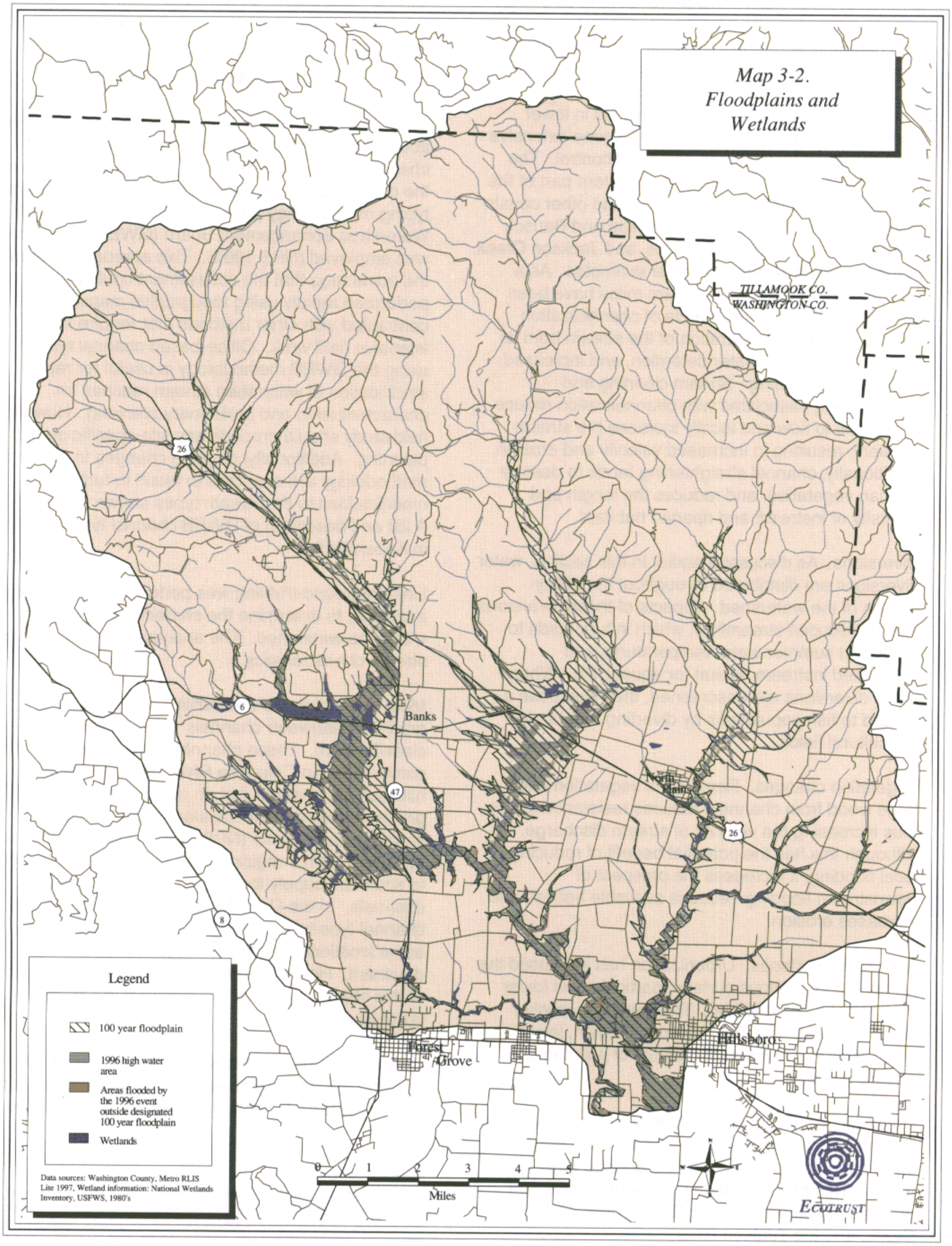
[2]Derived from analysis of GIS 1:24,000 streams layer. Includes current mileage of streams that have been obviously straightened, along with canals that may not have been part of the original stream system. Does not include less visibly straightened streams, nor channel cleaning unaccompanied by straightening operations.



Map 3-2.
Floodplains and Wetlands
TILLAMOOK CO.
WASHINGTON CO.
26
6
Banks
47
North Plains
26
8
Forest Grove
Hillsboro
Legend
100 year floodplain
1996 high water area
Areas flooded by the 1996 event outside designated 100 year floodplain
Wetlands
Data sources: Washington County, Metro RLIS Lite 1997, Wetland information: National Wetlands Inventory, USFWS, 1980's
0
1
2
3
4
5
Miles
ECOTRUST

as transport reaches, the narrow canyon walls provide a ready source of debris flows and colluvial sediment to the stream channel. Stream channels are confined by these channel walls and thus tend to have a low sinuosity.

On larger streams, the canyons widen and the channel type changes to "moderate gradient constrained channel" (GWEB type MC). Another transport reach, these areas will be less susceptible to direct colluvial inputs and grade into situations where streambank erosion gains importance. These reaches also have low sinuosity, as hillslopes continue to constrain the channel.

MC channels tend to grade into "moderate gradient, moderately constrained channels" (Type MM). Depositional processes become most important in this type of strea, although streambank erosion is prominent. In these channel types, transition occurs from a cobble-gravel substrate to a substrate dominated by fine sediments.

In the Tualatin Plain, low gradient streams with broad floodplains (GWEB types FP1 and FP2) dominate the channel forms. These streams generally have a high sinuosity and are dominated by depositional processes. Streambank erosion is an important erosional process in these reaches. Where bare soils occur near channels, sheet, rill, and gully erosion are also important contributors of sediments to streams.

Fisheries surveys cited by USA (1995) found a reach of East Fork Dairy Creek near Greener Road to be the best of the surveyed streams in terms of both habitat and fish diversity. However, the habitat summary shows considerable opportunity for improvement in this reach. In this 409 meter (1,340 foot) reach, most of the habitat (61%) was riffles and only 1% pool, with the remainder as glides. Despite the low incidence of pools, habitat diversity compared favorably with other surveyed reaches, which tended to be 100% glide or 100% riffle. (The surveyed length of these reaches varied from 178 to 2102 meters). Thirty-six percent of the surveyed upper Dairy Creek reach had cobble or gravel substrate, with an additional 52% in boulders and bedrock. Most other surveyed reaches were dominated by soil substrates. None of the bank in this reach was eroding. Canopy cover was 88%, much higher than the other sites. 3.8% undercut banks existed on this reach. The wood index, as with all surveyed reaches, was very low, indicating a lack of habitat complexity.

In 1994, BLM conducted more extensive surveys in upper reaches of the East Fork Dairy Creek and McKay Creek. In general, they found conditions similar to those cited in the USA survey. Although habitats were typically riffle dominated, they found a greater proportion of pool habitat than was cited in USA (1995). They also found substantial bank erosion. Stream canopy generally exceeded 70%, and was as high as 95% in some reaches. Instream large wood was deficient in most reaches.

The channels within the valley are deeply entrenched, and are typically dominated by glides, although sizeable pools have been reported by field researchers. In most cases, these channels are deficient in instream large wood.

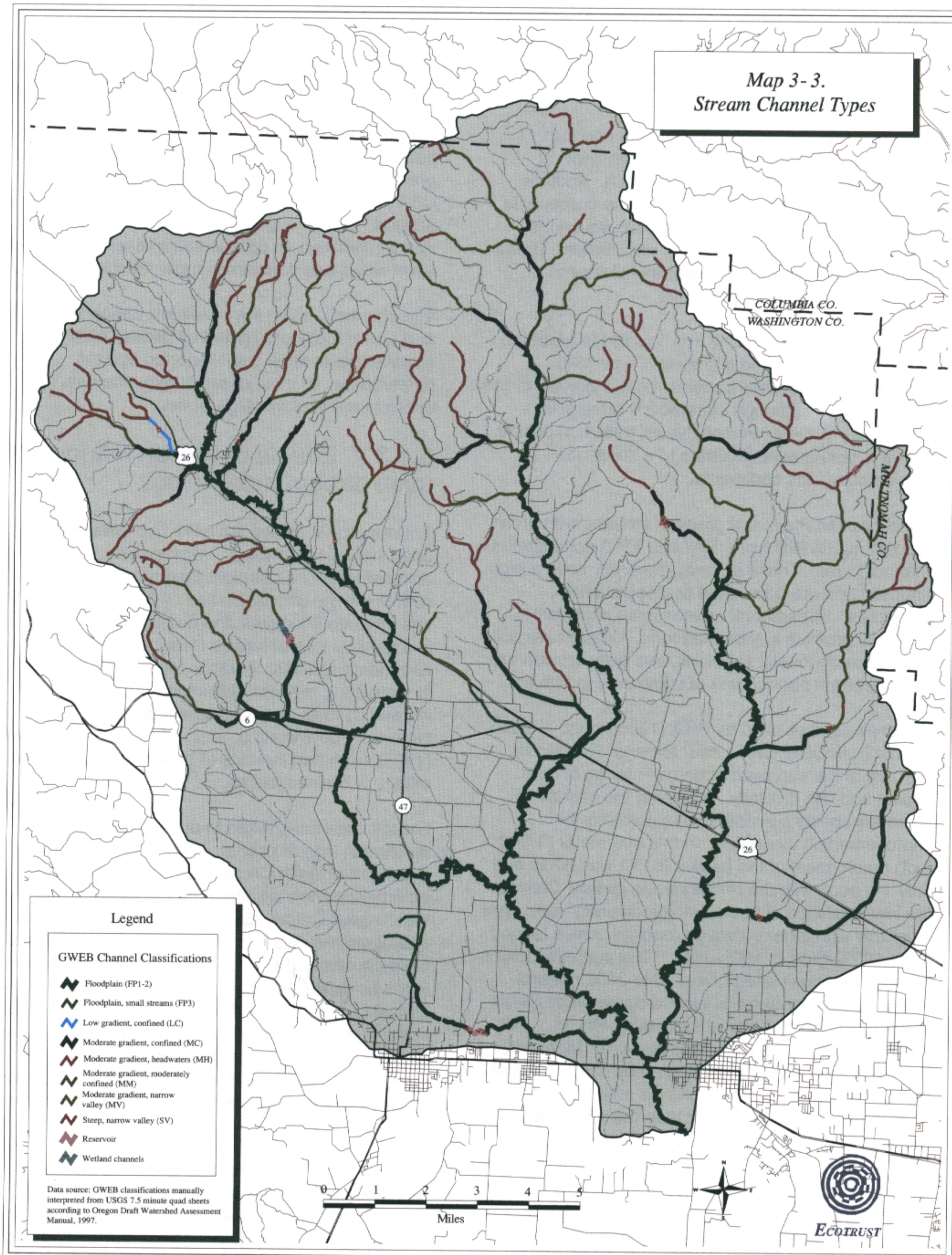
3.1.3.2 Effects of human influences upon stream morphology

Anthropogenic influences have had several effects upon stream morphology. Most notably, channelization has straightened naturally sinuous streams in the alluvial portion of the watershed. This has reduced floodplain and riparian area, and resulted in a general loss of habitat for aquatic and riparian-dependent species. Additionally, channel straightening reduces stream length, thereby increasing local stream gradient and potentially increasing downcutting. In the Tualatin basin, USA (1995) attributed the lack of undercut banks to the effects of channelization.

Locally, measures taken to protect roads have resulted in loss of habitat. A prime example is on the East Fork of Dairy Creek near Little Bend, where emergency channelization measures were taken by Washington County during the 1996 flood. These measures resulted in a severe reduction of habitat diversity along this reach. Population surveys taken in the early 1990s also showed this to be one of the best areas for salmonid production and rearing habitat in the Tualatin Basin. Although no population surveys have been conducted since 1996, loss of habitat through this channelization project can be expected to have a detrimental impact upon fisheries resources in this reach.

The Dairy-McKay Hydrologic Unit Area partnership has taken efforts to improve stream channel characteristics in the watershed. For example, the West Fork Soil Bioengineering Project utilized such techniques as tree plantings and placement of brush

[3]Channels are typed according to their unmodified characteristics. Where channel structure has been extensively modified, the probable type of the unmodified channel was reconstructed based on gradient and floodplain characteristics. Channel modifications are addressed at a separate stage of the GWEB methodology.



Map 3- 3.
Stream Channel Types
COLUMBIA CO.
WASHINGTON CO.
MULTNOMAH CO.
26
6
47
26
Legend
GWEB Channel Classifications
Floodplain (FP1-2)
Floodplain, small streams (FP3)
Low gradient, confined (LC)
Moderate gradient, confined (MC)
Moderate gradient, headwaters (MH)
Moderate gradient, moderately confined (MM)
Moderate gradient, narrow valley (MV)
Steep, narrow valley (SV)
Reservoir
Wetland channels
Data source: GWEB classifications manually interpreted from USGS 7.5 minute quad sheets according to Oregon Draft Watershed Assessment Manual, 1997.
0 1 2 3 4 5
Miles
N
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mattresses to control bank erosion and enhance channel characteristics. Use of these techniques resulted in increased shading and better fish habitat than those afforded by traditional riprap techniques.

3.1.4 Water quality

3.1.4.1 Beneficial uses

The major beneficial uses of water in Dairy Creek are for domestic and municipal consumption, cold water fisheries, recreation, irrigation, manufacturing, livestock watering, and wildlife. Water rights are summarized in the hydrology/water quantity section (Section 3.1.2.2). The water quality parameters that these beneficial uses are dependent on include water temperature, nutrient levels, suspended sediment/ turbidity levels, dissolved oxygen and bacterial levels.

3.1.4.2 General indicators of water quality

Generally speaking, the best water quality occurs in the forested portion of the watershed. Streams here are comparatively well shaded, and stream turbulence leads to well-oxygenated waters. However, little consistent data monitoring has taken place in this portion of the watershed.

Macroinvertebrate surveys provide an excellent indicator of water quality, sedimentation, habitat diversity, and biodiversity. Although such surveys have rarely been performed within the Tualatin basin, existing data indicates good water quality in upper reaches of the watershed, with lower water quality downstream. In surveys conducted in 1996 and 1998, researchers at Pacific University found that 69% (1996) and 80% (1998) of the macroinvertebrates in "upper" Tualatin Basin sites consisted of pollution intolerant taxa of orders *Ephemoptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies) (J. Greenberg and B. Duff, Pacific University, unpublished data). At lower basin sites, these taxa constituted 23.2% (1996) and 40% (1998) of the macroinvertebrate sample[4]. The survey sites for this study included one "upper" site on East Fork Dairy Creek near Meacham Corner, and a site on lower Dairy Creek. Although individual data for these two sites were not immediately available, the population characteristics at these sites were similar to those at "upper" and "lower" sites elsewhere in the basin. These studies yield similar results to those of earlier surveys conducted by Sutherland, ODEQ, in May and July of 1976. These surveys were performed at two sites, in upper McKay Creek near Shadybrook, and on the East Fork Dairy Creek near Meacham Corner. At both sites, he found diverse invertebrate species, including mayflies, stoneflies, and caddisflies (Sutherland 1976, as cited in ODEQ and USA 1982).

In downstream portions of the watershed, water quality typically decreases. The sluggish, meandering streams in the Tualatin Plain typically have higher temperatures and lower dissolved oxygen than do the mountainous reaches. The erodible silt banks, as well as sediments transported from upland sites, are conducive to heavy sediment loads and high stream turbidity. In these agricultural zones, high levels of nutrients and bacteria are also a potential problem.

To address water quality problems, ODEQ, USA, TVID, and the Oregon Graduate Institute (OGI) began a cooperative study of pollution sources and water quality in the Tualatin Basin. In one portion of this study, USA measured water quality parameters at several sites within the Dairy-McKay watershed (Aroner 1998). (Table 3.4). Intensive monitoring took place at two sites in the lower portions of the Dairy-McKay watershed. These sites were Dairy Creek at Highway 8 and McKay Creek at Hornecker Road. The study found that water quality, as measured by the Water Quality Index (WQI), rated considerably better at these Dairy Creek sites than in most other watersheds in the Tualatin Basin (Aroner 1998). Nevertheless, the WQI demonstrated poor water quality at these sites.

3.1.4.3 Streams on the 303(d) list

An estimated 69 miles of stream in the Dairy-McKay watershed are on the ODEQ 303(d) water quality limited list (Map 3-4). These include:

Council Creek, where dissolved oxygen is considered limiting to Cool Water Aquatic Life from May to October;

Dairy Creek below the confluence of the east and west forks. This reach of Dairy Creek has excessive *E. coli* counts year-round, and has summer temperatures that are limiting to cool-water aquatic life;

East Fork Dairy Creek, from the mouth to Whisky Creek, where low summer pH and high temperatures impair water quality;

West Fork Dairy Creek, which has high *E. coli* counts in summer. Additionally, high water temperature and low dissolved oxygen are limiting to cool water aquatic life in summer;

Table 3-4. USA monitoring sites in the Dairy-McKay watershed. Adapted from Aroner 1998.

USA location code	EPA Code	Stream	Location	Samples per year 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
3815021	3815020	Dairy Creek	Hwy 8	1	1	1	1	1	1	2	12	12	34	32	68	102	68	39	40	36	25
3815085	3815083	Dairy Creek	Verboort																		
3816020	3816024	McKay Creek	Hornecker										11	25	14		13	26	27	25	25
3816160		McKay Creek	Northrup												9		13				
3816080		McKay Creek	Sunset										11	12							
3817020	3817040	West Fork Dairy Cr.	Evers Road										11	12	14						
3817063		West Fork Dairy Cr.	Highway 6										11	12	12		13				
3817078	3817070	West Fork Dairy Cr.	Banks TP D/S	1	1	1	1	1	1												
3817079	3817171	West Fork Dairy Cr.	Banks TP U/S										11								
3817092		West Fork Dairy Cr.	Sunset Hwy										11	12	14						
3818014		East Fork Dairy Cr.	Roy Road												12		12				
3818084		East Fork Dairy Cr.	Dairy Creek Rd																		
3818168		East Fork Dairy Cr.	Fern Flat Rd																		

Non USA monitoring sites

Station	Agency	Stream	Location	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
14206200	USGS	Dairy Creek	Hwy 8												3			2			
3816160	ODA	McKay Creek	Northrup Rd															12	13	12	13
3816230	ODF	McKay Creek	Pumpkin Ridge Rd												13	10	2	8			
3817040	ODA	WF Dairy Creek	Evers Rd										11	12	15	2					
3818084	ODA	EF Dairy Creek	Dairy Creek Rd															12	13	12	13
3818168	ODF	EF Dairy Creek	Fern Flat Rd												13	7		8			
3818209	ODF	EF Dairy Creek	County Line												13	10	2				

McKay Creek, from the Mouth to East Fork, summer water temperatures are a concern. Additionally, high *E. coli* levels prevail throughout the year.

3.1.4.4 Parameters of concern

3.1.4.4.1 Bacteria

E. coli is an important indicator of inputs of fecal bacteria to stream systems. High bacteria levels can cause disease, and restrict the beneficial uses of water for humans, such as water contact recreation. Studies by USA indicated that elevated bacteria levels in rural areas are largely the result of livestock farms with inadequate manure storage, manure management, or grazing management (Aroner 1998). It is possible that poorly placed septic systems may also contribute to the problem.

3.1.4.4.2 Dissolved Oxygen

High levels of dissolved oxygen are essential for most types of aquatic life. Dissolved oxygen levels are affected by temperature and aquatic growth. High temperatures lead to lower dissolved oxygen levels, while decomposition of organic matter, such as algae, consume oxygen, leading to low levels of instream dissolved oxygen. As gases are often most easily transferred in turbulent waters, lack of turbulence can also lead to low dissolved oxygen levels.

During cooperative monitoring efforts, low May to October dissolved oxygen (D.O.) was measured in McKay Creek (at Hornecker Road). Within the May-October 1997 measurement period, this site had D.O. readings below the 6.5 mg/L criteria for cool water streams. Between 10 and 25 percent of all measurements recorded low oxygen levels (Aroner 1998). Additionally, McKay Creek had some of the highest Total Chemical Oxygen Demand (TCOD) measurements among Tualatin River tributaries.

Examination of 1998 aerial photography on Farm Service Agency (FSA) slides showed that Council Creek was heavily channelized and had consistently poor riparian cover. Any water flowing during the summer months would incur high levels of exposure to solar radiation. Additionally, several impoundments exist along the 10 mile course of the stream. These impoundments allow water increased residence time and exposure to solar radiation. Field visits indicated that the water outside of impoundments was stagnant, as well.

[4]Survey methodology varied between the two years.

3.1.4.4.3 Phosphorus

In many natural aquatic systems, phosphorus is limiting to aquatic growth. When streams are enriched by phosphorus inputs, it can lead to algal blooms, decreased dissolved oxygen, fish kills, and bad odors.

Phosphorus is a major parameter of concern within the Dairy-McKay watershed. The majority of stream sampling points show phosphorus levels that exceed TMDL standards.

3.1.4.4.3.1 Potential sources of phosphorus

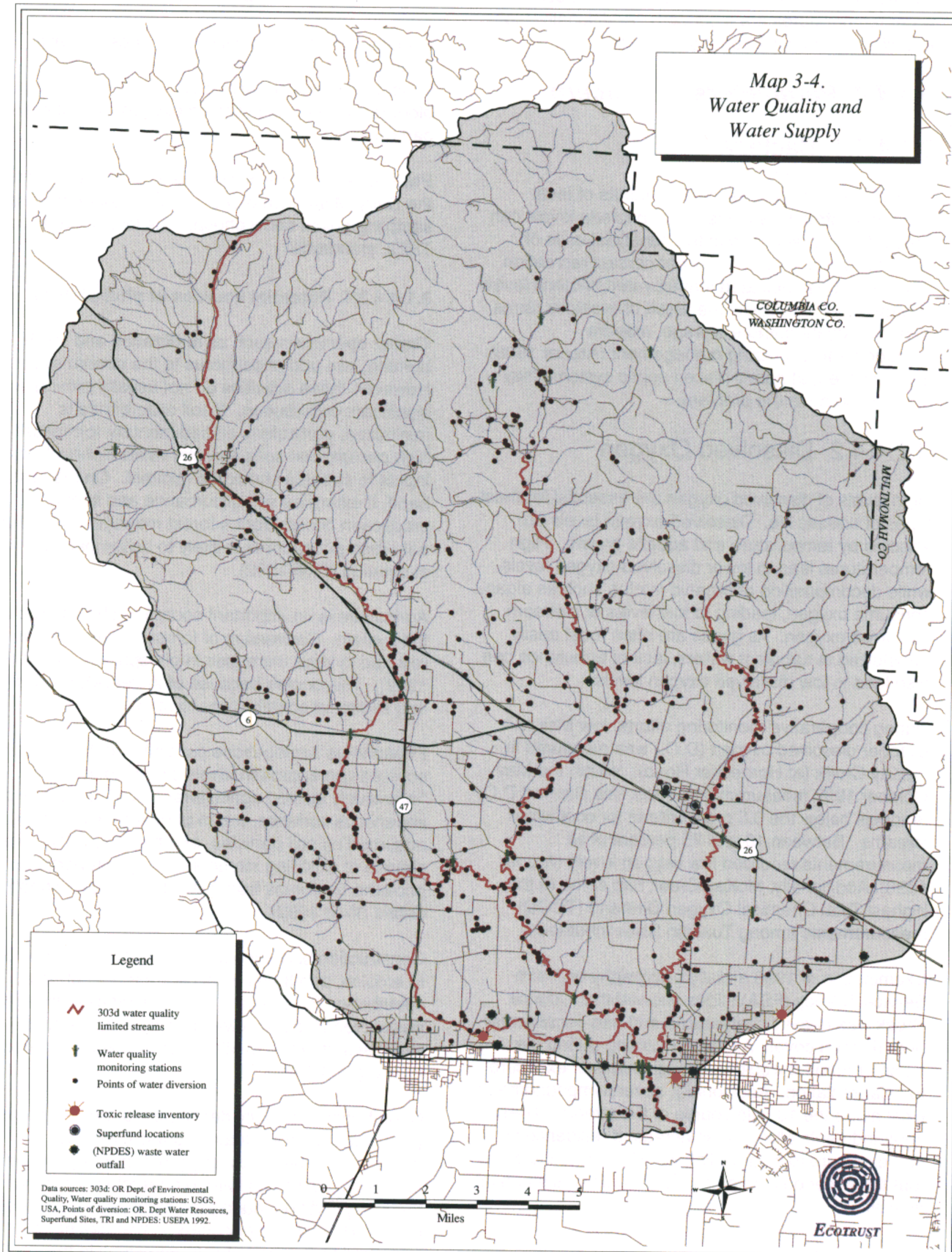
Timber operations such as fertilization and slash burning, can add phosphorus to the stream system. However, these activities do not usually provide a significant contribution. If soil disturbance is minimized, particularly on sedimentary formations and high phosphorus soils, forestry-related phosphorus inputs to streams should be minimal. On the other hand, if extensive soil disturbance and sediment production occurs from a forest management activity, adsorbed phosphorus is likely to accompany the sediments (Wolf 1992).

Agriculture is an important source of phosphorus to the system. Conversion of forest to farmland has resulted in large increases in phosphorus export (Wolf 1992). This occurs because of increased fertilizer use and sediment contributions to streams.

Phosphorus contributions per unit area from urban sources can approach levels similar to those for "intensively farmed agricultural areas". Because of impervious surfaces, urban phosphorus is not readily adsorbed by soil particles, and thus has an increased chance of reaching streams. A large proportion of this phosphorus comes from leaching of organic trash and debris (Wolf 1992).

Construction bares the soil, thus making it vulnerable to erosion, and thus can accelerate phosphorus contribution to streams. Various studies performed at diverse locations worldwide list stream phosphorus increases of 148% to 6000% over predevelopment levels. (Wolf 1992)

Contributions of easily decomposed organic matter (e.g. manure, straw, leaves, grass clippings) increases the biological oxygen demand (BOD) of sediments. This can lead to anaerobic conditions in the stream bottom during the summer, which tends to chemically mobilize phosphorus that has been adsorbed to iron and aluminum oxides in the sediments.


Map 3-4.
Water Quality and
Water Supply
COLUMBIA CO.
WASHINGTON CO.
MULTNOMAH CO.
26
6
47
26
Legend
303d water quality limited streams
Water quality monitoring stations
Points of water diversion
Toxic release inventory
Superfund locations
(NPDES) waste water outfall
Data sources: 303d: OR Dept. of Environmental Quality, Water quality monitoring stations: USGS, USA, Points of diversion: OR. Dept Water Resources, Superfund Sites, TRI and NPDES: USEPA 1992.
0 1 2 3 4 5
Miles
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3.1.4.4.3.2 Distribution of phosphorus in the Dairy-McKay watershed.

Much of the phosphorus in streams in the Dairy-McKay watershed arises from natural sources. In 1990 and 1991, the Oregon Department of Forestry conducted phosphorus monitoring in forest streams, including the East Fork of Dairy Creek. During this monitoring, they established that phosphorus levels were higher in some forested sites than in adjacent downstream monitoring sites. The source for this phosphorus was determined to be natural mineral deposits dissolved in groundwater, rather than anthropogenic sources. High phosphorus levels were associated with sedimentary formations, while the Columbia River basalt was associated with low phosphorus levels. Phosphorus levels were particularly high in summer low flows, when the diluting effect of precipitation was not available.

Natural groundwater sources appear to be the major cause of high phosphorus levels in the Tualatin Plain, as well. Regional[5] groundwater flow in the alluvial plain flows through sediments naturally enriched in phosphorus. In these deep sediments, groundwater concentration of phosphorus typically attains levels of 0.2-3.0 mg/L. As the groundwater moves through near-surface soil layers, much of this phosphorus is removed from the water as it achieves equilibrium with the surrounding soil. Equilibrium levels appear to be around 0.1 to 0.2 mg/L (TAC 1997). In summer, dissolved phosphorus from groundwater sources appears to account for most of the phosphorus in surface streams (TAC 1997).

Evidence suggests that anthropogenic sources of phosphorus in the Dairy-McKay watershed are not leaching significantly through soil to the 3-5 foot depths where subsurface drains are placed (Abrams 1995). Studies in other locations indicate that phosphorus leaching to tile drains is possible and is related to soil phosphorus levels (Beauchemin 1997). Soil test reports show that very high levels of soil phosphorus on livestock and specialty crop farms in the Dairy-McKay watershed, indicating a history of high manure and fertilizer applications (NRCS, Hillsboro, unpublished data). The critical levels at which soil test phosphorus will lead to significant leaching of phosphorus to tile drains in the Dairy-McKay watershed is unknown. The significance of such potential leaching, however, is that tile drains often flow into streams well into the summer months when phosphorus loading is undesirable.

Most of the current anthropogenic phosphorus load enters streams during winter surface runoff events, either in the dissolved state or adsorbed to eroding soil particles. It is unknown how much, if any, of these winter loads of phosphorus remain in the system (e.g. as bottom sediments) and are released during summer months.

Examination of 1997 monitoring records shows that some headwater reaches of Dairy Creek have phosphorus levels within TMDL standards. However, both forks of Dairy Creek have phosphorus concentrations well above TMDL standards for the lower and middle reaches. High levels begin in the forested reaches of these streams, and are consistent with a hypothesis that these levels are caused by the naturally high phosphorus content of the underlying sedimentary formations. As the forks of Dairy Creek flow downstream, the stream receives additional phosphorus inputs both from naturally enriched groundwater and agricultural operations. Although both forks achieve high phosphorus levels, this trend is much more apparent in the West Fork of Dairy Creek. This is probably because of the greater mileage of stream that flows through alluvial lands. Due to the high natural phosphorus levels, TMDL goals in Dairy Creek do not appear to be achievable. However, agricultural loading can be decreased by addressing sediment, fertilizer, and manure issues. Reduced fertilizer use may also effect minor reductions in summer phosphorus concentrations.

McKay Creek has low phosphorus levels throughout the forested portion of its course. This is probably due to the low phosphorus levels of the underlying basaltic bedrock. At Northrup Road, near the head of the alluvial plain, McKay Creek's phosphorus levels are near the TMDL standard. As McKay Creek passes through alluvial lands, it rapidly gains phosphorus. At Hornecker Road, it reaches very high levels, about twice the TMDL standard. The potential for further phosphorus reductions seems limited. Water quality above Northrup Road will probably continue to achieve TMDL standards for phosphorus, while downstream stations will probably continue to exceed these standards. Improvement efforts focused on agricultural inputs are likely to achieve reductions in winter phosphorus loads. Significant reductions in summer concentrations may not be possible.

For both Dairy and McKay creeks, it makes sense to match manure and fertilizer phosphorus applications to crop needs. This should reverse the trend toward

[5]Regional groundwater typically flows at a depth of 100-1,500 feet through older (Tertiary) sediments. It is distinguished from groundwater flowing through "near-surface" and "local" pathways by its greater depth, longer residence times, and longer travel pathways "Deep" groundwater is stored in the underlying bedrock and does not tend to interact with surface flow.

higher soil test phosphorus levels, thereby reducing the risk of both phosphorus-enriched surface runoff and future phosphorus leaching.

3.1.4.4.4 Stream temperature

In the Tualatin Basin, concern over water temperature generally relates to the fitness of streams to provide suitable conditions for cold water aquatic species, such as salmonids. For most streams in the basin, the cool water standard of 17.8 C (64º F) is applied.

In conjunction with their monitoring plan, USA measured spot water temperatures at two sites on the lower reaches of Dairy and McKay creeks (Appendix 2). As these sites are near the base of the watershed, they express the results of cumulative heating over the course of the watershed. Temperature at both sites regularly exceeded the 17.8 C cool water standard. Between May and October of 1997, more than 25% of temperature measurements exceeded this standard (Aroner 1998).

Between the East Fork of McKay Creek and Highway 26, McKay Creek has a thin riparian buffer, usually consisting of one tree width (Appendix 6). This reach would be subject to increased inputs of solar radiation as compared to areas of dense riparian cover. Additionally, several tributaries have channelized reaches with very little riparian cover. Jackson Creek, near its confluence with McKay Creek, is a notable example.

3.1.4.4.5 Other parameters of concern

More than half of May-November 15 observations exceeded ammonia TMDL criteria at McKay and East Fork Dairy Creek stations. High ammonia levels are often associated with faulty septic systems and access of animal wastes to stream systems. The data suggest a trend toward decreasing ammonia at most Tualatin Valley sites, including McKay and Dairy creeks (Aroner 1998). They noted that problems associated with ammonia toxicity are greatest in the summer as the highest instream ammonia concentrations occur at that time of year.

3.1.4.5 Water quality trends

The USA study, (Aroner 1998), found several notable water quality trends in the Tualatin Basin. Those shared by Dairy Creek include:

- Decreasing total phosphorus
- Decreasing soluble ortho-phosphate
- Increasing temperature
- Decreasing ammonia
- Decreasing total dissolved solids

Additionally, Dairy Creek at Highway 8 had statistically significant declining trend for Nitrate + Nitrite and Total Chemical Oxygen Demand (TCOD). These characteristics appear to indicate improving water quality, although the temperature trend is disturbing.

Over the course of the USA cooperative monitoring study, year-round and November to April water quality index (WQI) trends were found to be significantly improving. Comparison of these results with a previous study conducted by USA and ODEQ (1982) confirmed this trend of improvement in the WQI. During the 1970s, Dairy Creek at Highway 8 had an Oregon WQI value of 66 in 1970-74, and 65 in 1978-79. During the period 1991-1997, mean WQI for this site improved to 78 (Aroner 1998).

3.1.4.6 Superfund sites

Three sites fall under the provisions of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA), also known as the Superfund. These sites are located in North Plains. Two of these sites, The Dant and Russell Burlington Northern site, and the Vadis pole yard, were found to have hazardous wastes needing removal. Following hazardous waste removal, the EPA removed these sites from the CERCLA list. For the third site, FERAD Inc., emergency waste removal was not considered necessary, and this site was also removed from the list.

3.1.5 Aquatic species and habitat

3.1.5.1 Cold-water fish

3.1.5.1.1 Distribution and life history

Dairy Creek is one of the most important fish-supporting tributaries of the Tualatin River. East Fork Dairy Creek, in particular, is considered by the Oregon Department of State Lands (ODSL) to be essential salmonid habitat. Dairy Creek and its tributaries support several salmonid species including cutthroat trout, steelhead trout, and coho salmon. Cutthroat and steelhead trout are native to the system. Coho salmon were first introduced in the 1920's and have since become naturalized (ODEQ and USA 1982). Common native non-salmonids include dace and sculpin. Pacific lamprey and brook lamprey are also present. A list of fish species within the watershed is given in Table 3.5.

Table 3-5. Anadromous and resident fish known to inhabit the Dairy Creek Watershed

Anadromous Fish		Resident Fish	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Coho salmon	*Oncorhynchus kisutch*	Cutthroat trout	*Oncorhynchus clarki*
Steelhead trout	*Oncorhynchus mykiss*	Western brook lamprey	*Lampetra richardsoni*
Pacific lamprey	*Entosphenus tridentatus*	Reticulate sculpin	*Cottus perplexus*
		Torrent sculpin	*Cottus rhotheus*
		Redside shiner	*Richardsonius balteatus*

Cutthroat trout are relatively abundant in the Dairy-McKay watershed. The East and West forks of Dairy Creek have been found to be the main cutthroat trout spawning and rearing areas in the Tualatin basin (SRI 1990). During 1994-95 population surveys, ODFW found cutthroat trout to be distributed throughout the watershed.

Although steelhead trout are not numerous in the watershed, they are known to rear in the East Fork of Dairy Creek, West Fork Dairy Creek, Burgholzer Creek, McKay Creek, and Jackson Creek (Map 3-5, fish distribution maps). Additionally, suitable habitat for these fish is found in tributaries of these streams, but presence of steelhead trout has not been verified in these tributaries.

An index of biotic integrity (IBI) was formulated, based on the characteristics of fish communities within a reach. Using this index, USA (1995) found community structure at the surveyed site of Middle Dairy (Roy Road to railroad bridge), to be poor, while the Upper (East Fork) Dairy Creek site (Greener Road to Little Bend Park) had a well-developed community structure.

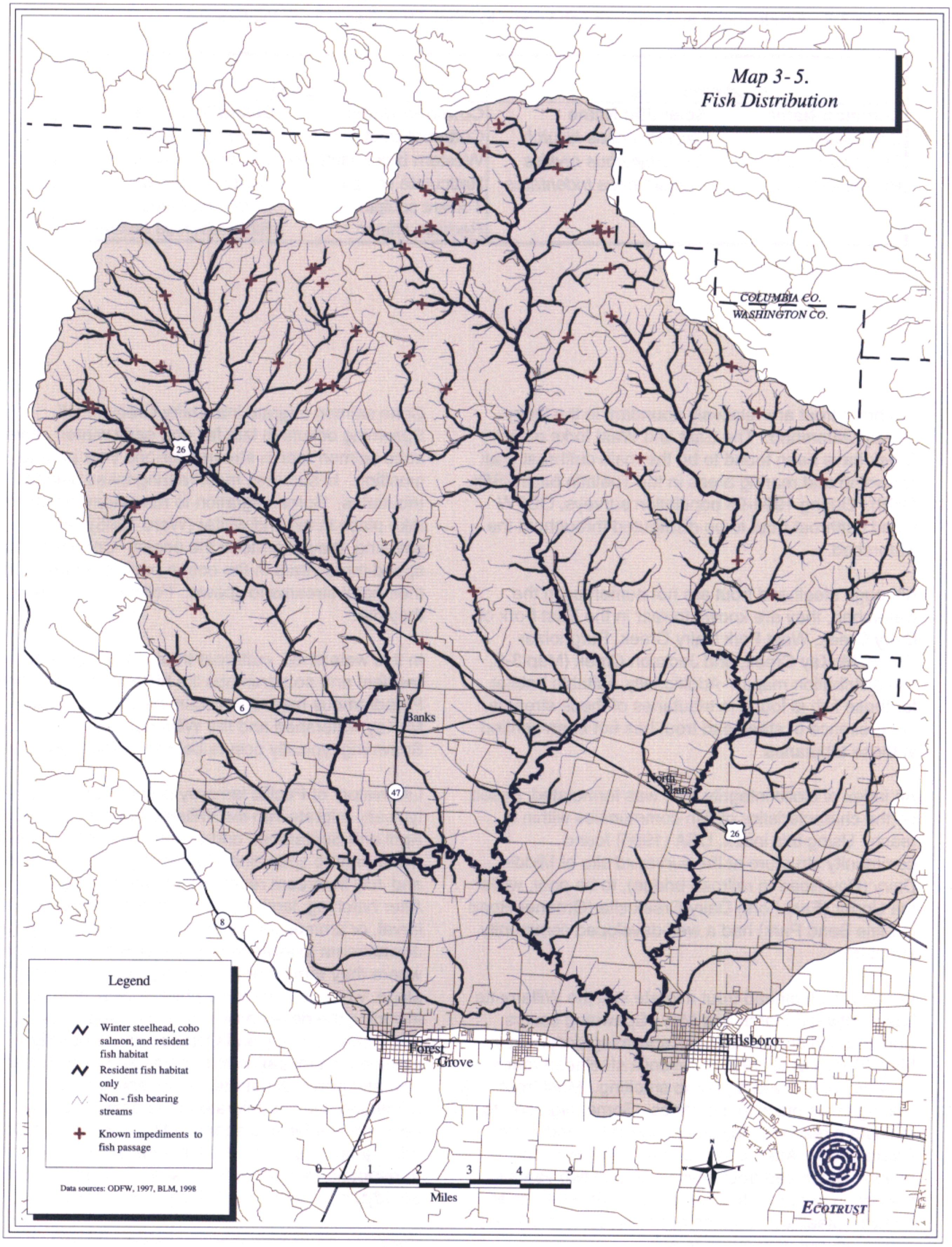
Winter run steelhead trout migrate into the Willamette basin between March and May. Spawning occurs April through June, with peak spawning occurring in May. (Busby et al. 1996). Juvenile steelhead rear in streams for two years prior to smolting. Most trout rearing takes place in tributaries. Some migration to mainstem reaches may take place in fall and winter (Ward 1995). After smolting, they migrate to the ocean. Steelhead trout typically spend two years in the ocean prior to returning to their natal streams to spawn. Steelhead trout do not necessarily die after spawning, but may return to sea.

Coho salmon migrate into Dairy Creek in fall. Spawning occurs in late fall and early winter. Juvenile coho salmon rear in streams for one year prior to smolting. In summer, most rearing takes place in tributaries. Some migration to mainstem reaches may take place in fall and winter (Ward 1995). After smolting, they migrate to the ocean. Coho typically spend three years in the ocean prior to returning to their natal streams to spawn. Following spawning, they die.

In this watershed, cutthroat trout exhibiting both resident and potadromous life histories are present[6]. Potadromous migration occurs between the Dairy-McKay watershed and the Willamette River. Spawning typically occurs between March and June.

Life history of Pacific lamprey is complex. They typically migrate into the Willamette basin between April and September, and spend one winter in fresh water prior to spawning. Spawning occurs in June and July in stream reaches with abundant gravel. After hatching, lamprey spend four to six years in the larval, or ammocoete, stage. Ammocoetes migrate downstream to lowland reaches with mud substrates, where they remain until attaining juvenile stage. This stage, which is marked by physiological changes including the development of eyes, usually takes place between July and October, and is usually marked by a migration to stream reaches with fast flow and gravel substrate. As juveniles grow to adulthood, they outmigrate to the ocean, usually between late fall and spring. Off of the Oregon Coast, adult lamprey spend 20-40 months in the ocean prior to returning to fresh water to spawn. They die three to 36 days after spawning (Close et al. 1995).

[6] *Potadromous* fish practice seasonal migration within a stream system for spawning purposes, but remain in fresh water throughout their life history.


Map 3-5.
Fish Distribution
COLUMBIA CO.
WASHINGTON CO.
26
6
Banks
47
North Plains
26
8
Forest Grove
Hillsboro
Legend
Winter steelhead, coho salmon, and resident fish habitat
Resident fish habitat only
Non - fish bearing streams
Known impediments to fish passage
Data sources: ODFW, 1997, BLM, 1998
0 1 2 3 4 5
Miles
ECOTRUST

3.1.5.1.2 Potential hazards

For anadromous fish, in particular, habitat is limiting. There is an estimated 12 to 15 miles of spawning habitat accessible to anadromous fish. Most of the best rearing habitat also lies within the reaches used for spawning. Since the amount of habitat is so limited, any degradation is significant. Threats to salmonid habitat in the watershed include loss of habitat diversity, elevated water temperatures, and low summer and fall streamflow.

Additionally, migratory impediments, stream diversions, predation, and competition are factors affecting salmonid populations.

3.1.5.1.3 Planting of hatchery salmonids.

Steelhead trout and coho salmon were released into McKay Creek and its tributaries between 1983 and 1986. Over this period, 82,159 steelhead trout smolts were released in the mainstem of McKay Creek. The coho salmon plants were distributed between the mainstem and several tributaries, with 164,714 coho salmon fry and pre-smolts planted in the mainstem, 47,080 planted in Jackson Creek, and 47,080 planted in the East Fork of McKay Creek over the four year period (SRI 1990). Current ODFW policy prohibits stocking of salmonids to protect native cutthroat trout stocks.

3.1.5.1.4 Prospects for salmonid populations.

Dairy and McKay creeks fall within the upper Willamette Evolutionarily Significant Unit (ESU) for steelhead trout. Steelhead trout within this ESU are as threatened under the Endangered Species Act (ESA) listed. Through genetic analysis, the National Marine Fisheries Service (NMFS) determined that the steelhead trout in the Dairy Creek are of native stock, indicating that they will be included in the ESA listing. Although Nehlsen et al. (1991) did not consider these steelhead trout stocks to be at risk, more recent trends indicate a possible decline in population. Wide population fluctuations make trends difficult to determine. However, low populations indicate a possible risk of extinction (Busby et al. 1996).

Coastal cutthroat trout within the upper Willamette ESU are a candidate species for listing under the ESA. Although much of the concern circulates around anadromous cutthroat trout, no distinction is made between sea-run and resident cutthroat trout regarding the ESA listing (Greg White, personal communication). Population trends for Dairy Creek cutthroat trout are unknown, but the large number and widespread distribution of these fish makes near-term extinction unlikely.

3.1.5.1.4.1 Non-salmonid populations and trends.

Little population information is available on non-salmonid fish species in the watershed.

3.1.5.1.5 Distribution of habitat

Coho salmon, steelhead and cutthroat trout vary in their seasonal habitat utilization but all require structurally diverse channels for the maintenance of healthy populations. In general, coho salmon occupy middle stream reaches while cutthroat and steelhead trout occupy upper reaches. During high flow periods associated with winter and spring, juvenile coho salmon, steelhead and cutthroat trout depend on the low velocity habitats provided by pools, backwaters, and off-channel alcoves. Adult salmon and trout also use pools and wood structure for shelter from predators and for resting. During low flow periods zero to one year old steelhead and cutthroat trout inhabit higher velocity areas associated with riffles, while coho salmon continue to use pools. Two year and older steelhead and cutthroat trout generally prefer the deepest pool habitat.

In coast range streams, large wood pieces and accumulations play a vital role in maintaining channel complexity and fish populations. Large woody debris (LWD) creates scour, recruits and maintains spawning gravel, creates rearing pools and increases channel complexity. In the Dairy-McKay watershed, elements of structurally diverse habitat are frequently missing due to the lack of LWD in the stream channel and floodplain.

In the Dairy-McKay watershed the most suitable habitat conditions are found in the mountainous, forested reaches. Although pool habitat is somewhat limited, these reaches typically have rocky substrates and fast flowing, well oxygenated water. They offer the best spawning gravels, relatively cool water, better canopy, and more diverse habitats than downstream reaches. Aquatic invertebrates also appear to be abundant in these reaches, offering a food source for these fish. Suitable habitat of this type is found in about five miles of the East Fork of Dairy, three miles of the West Fork, and eight miles of McKay Creek.

The East Fork of Dairy Creek, above Greener Road, has provided one of the best rearing habitats for salmonids and other pollution-intolerant fish within the Tualatin Basin. During surveys mentioned in USA (1995), this reach had the greatest number of such species of any sampled stream. These included the Pacific lamprey, cutthroat trout, steelhead trout, and torrent sculpin. This was the only sample location where torrent sculpin were found, although habitat seemed appropriate at several other sites. This site also contained 80.7% of all the steelhead and cutthroat trout found in the survey. However, recent channel modifications diminished the quality of habitat at this location. Channelization of this site during flood control efforts reduced the amount of potential spawning and rearing habitat. Additionally, it eliminated complex habitat components. The removal of large woody debris and straightening of the channel resulted in downcutting of four feet, leading to increased bank instability and erosion potential.

Lowland reaches typically have eroding banks, warm temperatures, high stream turbidity, silt substrate, and glide habitat. These characteristics generally reduce their suitability for salmonid habitat. However, isolated reaches of suitable salmonid habitat occur within this region. Greg White, CH2MHill, described one such area on an unnamed tributary of McKay Creek near Connell Road. At this site, he found "a large, deep pool that provides good rearing habitat". Downstream of the pool the substrate consisted of highly embedded pea-sized gravels. Mr. White concluded that these gravels would be suitable for spawning of resident salmonids, but would not provide suitable habitat for anadromous fish. Surveys performed in conjunction with the SWCD prohibited conditions assessments (Section 3.1.1.5 and 5.1.4.6) have noted reaches with good pools, which may offer seasonal opportunities for rearing (ODEQ and USA 1982, White 1996, SWCD unpublished data).

3.1.5.1.5.1 Habitats for non-salmonid species

As described in the life history section, Pacific lamprey have diverse habitat needs. They prefer cool water temperatures at all life stages. Substrate needs vary by life stage: During the ammocoete stage they utilize stream reaches with mud substrates. On the other hand, juveniles and adults need gravel substrates and flowing, well-oxygenated water. Thus, potential habitat concerns for lamprey involve a considerable portion of the Dairy-McKay watershed.

3.1.5.1.6 Migration barriers

Barriers to fish passage include both natural and anthropogenic factors. On most of the smaller tributaries, natural stream size is the limiting factor. In most other cases, migration impedance is partially or wholly due to human activities. Diversions can reduce stream depth and divert fish from the streams. Stream crossings can block fish passage, either through improperly placed culverts, or in some cases a lack of culverting.

Washington County performed a survey of 32 culverts within the watershed. Of these culverts, 20 were found to be structurally inadequate because of poor culvert condition, migratory impediment, or impaired passage of high flows (Appendix 7). Many of these culverts pose potential barriers to migration. Three of these culverts were identified as a high priority for replacement: Highway 26 at Mendenhall Creek, Road 135700 at Plentywater Creek, and Road 196200 at Murtagh Creek. An additional culvert, where Dixie Mountain Road crosses the East Fork McKay Creek, was inspected by ODFW personnel and found to be a barrier to fish passage. It is a high priority for replacement, but is structurally adequate. Due to the $300,000 cost of repairing a slide near this location, the culvert may not be replaced (Clemmons, Washington County).

3.1.5.2 Survey and manage mollusks.

Of the six mollusk species potentially found within the Tillamook Resource Area, none are known to inhabit Washington County. However, due to the limited knowledge of the range of many mollusk species the Area does conduct surveys of project areas within the watershed. The six species thought to occur in the Tillamook Resource Area are:

- *Cryptomastix devia*
- *Derocerus hesperium*
- *Hemphillia glandulosa*
- *Megomphix hemphilli*
- *Prophysaon coeruleum*
- *Prophysaon dubium*

3.1.5.3 Amphibians

Many amphibians depend on riparian and wetland habitats. Worldwide, the reduction in area of such habitats has resulted in a corresponding reduction in amphibian numbers. Additionally, native frogs in the Western USA have largely been outcompeted by the introduced bullfrog. Riparian-dependent amphibian species of interest in the Dairy-McKay watershed include the red-legged frog, tailed frog, Cope's giant salamander, and Columbia torrent salamander. The clouded salamander is also of interest, but it generally is associated with upland forested habitat, specifically snags, fallen trees, and rotten logs.

Red-legged frog (*Rana aurora*) (BS)

The red-legged frog is known to occur within the Dairy-McKay watershed. They generally breed in marshes, small ponds and slow-moving backwater areas although during the non-breeding season they are highly terrestrial, commonly venturing into forested uplands. Past forest management practices which involved altering cool, moist riparian and forest floor habitats, such as clearcut harvesting of riparian and upland areas, may have adversely impacted the quality and quantity of red-legged frog habitat within the watershed.
In 1994 and 1998, BLM personnel repeatedly sighted red-legged frogs along the East Fork of Dairy Creek. These sightings occurred between the headwaters and Big Canyon. Additionally, during the present study, field researchers observed a red-legged frog on the East Fork near Little Bend, as well as a large number of frogs on McKay Creek above the confluence with the East Fork of McKay Creek.

Tailed frog (*Ascaphus truei*) (BA, SV)

Tailed frogs were reported by Pacific University researchers to be present at a site on the East Fork of Dairy Creek (Jennifer Olds, Pacific University, unpublished data). This sighting occurred outside of the area normally considered to be the range of the tailed frog. It is likely that the highest potential for future sightings of the tailed frog would occur in the western portion of the watershed.
Important habitat types for tailed frogs include cold streams with rocky substrate and adjacent riparian forests. In portions of its range, this frog has experienced a severe decline in population. Increased stream temperatures and stream sedimentation from timber harvest and road building activities have been suggested as possible causes for this decline (Csuti et al. 1997).

Cope's giant salamander (*Dicamptodon copei*) (BS)

The Cope's Giant Salamander may potentially exist in the watershed. They would most likely be found in cold headwater streams and seeps in the northern portion of the watershed. This amphibian is almost always found in its larval form.

Columbia torrent salamander (*Rhyacottriton kezeri*) (BS)

It is likely that Columbia torrent salamanders are present in the watershed. Pacific University researchers reported an "Olympic salamander" (a synonym for the Columbia torrent salamander) to be present at a site on the East Fork of Dairy Creek (Jennifer Olds, Pacific University, unpublished data). This sighting occurred on the eastern fringe of the area normally considered to be the range of the Columbia torrent salamander. The highest potential for future sightings of these amphibians would occur in the western portion of the watershed.

3.1.5.3 Other Riparian and wetland-dependent species.

Riparian and wetland areas provide habitat for many bird species in the Dairy-McKay watershed. These include wood ducks and mallards, which nest in riparian areas. Seasonal flooding and farm ponds add to the available habitat for waterfowl. Species using such habitats include Canada geese, whistling swan, mallard, wood ducks, American widgeon, ring-necked duck, lesser scaup, green-winged teal, pintail, and American coot. (ODEQ and USA 1982).

3.2 TERRESTRIAL

3.2.1 Vegetation

3.2.1.1 Array and landscape pattern of vegetation

3.2.1.1.1 Vegetation in the Tualatin Plain

The portion of the watershed lying upon the valley plain is largely in agriculture. These agricultural areas comprise roughly 43% of the watershed[7]. Little natural vegetation exists in these areas, except for isolated windbreaks, and in riparian areas. Where such vegetation exists in upland zones, it is typically comprised of copses of Oregon white oak and Douglas-fir. In riparian areas, vegetation is often dominated by Oregon ash.

Width of the riparian buffer in the valley plain is quite variable[8]. Dairy Creek and McKay Creek (South of Highway 26) have wide riparian buffers over most of their extent (Appendix 6). The West Fork of Dairy Creek, Council Creek, and McKay Creek north of Highway 26 generally have severely compromised buffers. Smaller tributaries commonly have minimal buffers and are often channelized.

3.2.1.1.2 Vegetation in the Tualatin Mountains

The watershed area is within the western hemlock zone described by Franklin and Dyrness (1973). Subclimax Douglas-fir dominates most stands in the watershed. Over time, and in the absence of major disturbance, the eventual climax community would be dominated by western hemlock along with western redcedar. The few old-growth stands in this zone (400 to 600 years old), however, still retain a major component of Douglas-fir. The composition and density of seral forest stands in this zone depend on the type of disturbance, available seed source, and environmental conditions. A common situation, which is the case in the watershed area, is the development *of dense,* even-aged stands of Douglas-fir. This pattern is encouraged by extensively planting this species following timber harvest and intensively managing competing vegetation in the young developing plantations.

Several plant associations similar to those described for the Siuslaw National Forest by Hemstrom and Logan (1986) are common in the watershed area. These include western hemlock/salal, western hemlock/vine maple-salal, western hemlock/swordfern, western hemlock/vine maple/swordfern, and western hemlock/dwarf Oregon grape-salal.

In the absence of stand-replacing disturbances such as catastrophic fire, windthrow, or timber harvesting, most forest stands in the watershed can generally be expected to progress through a series of stand conditions after they initiate, leading to the eventual culmination in the old-growth stand condition. The first stand condition is called **grass-forb**. This condition occurs after regeneration timber harvest and slash disposal. The quantity of vegetation on the area is relatively low. The area is dominated by herbaceous vegetation for the first year. Shrubs have typically not yet become dominant, but basal sprouts from a number of shrub species are evident. Although these areas have been planted with conifer seedlings, the trees are typically too small to be apparent at this stage. This stand condition may last from 2 to 5 years. In harvested stands, the amount of snags and down wood and snags is limited to unmerchanteable material left after harvesting, which is in sharp contrast to the large quantity of snags and down wood and snags following a major natural disturbance.

Stands next move into the **shrub** stand condition, which can last from 3 to 10 years. Shrubs and trees assume dominance. Tree cover is typically less than 30 percent. Red alder often dominates portions of stands if not controlled, especially where mineral soil was exposed during logging or other disturbances. Red alder is favored by exposed mineral soil and full sunlight (Harrington et al. 1994). Basal sprouts from bigleaf maple may also attain site dominance if not controlled. Both of these species readily overtop young conifers because their rapid rates of growth greatly exceed that of young conifers.

The **sapling/pole** stand conditions begins at about stand age 15. When tree densities exceed about 500 trees per acre in the early portion of this stage, conifer stands are typically thinned to densities ranging from 200 to 300 trees per acre to promote rapid tree growth. Thinning at this time prolongs the understory shrub and herbaceous components in the stand, which otherwise would begin to decrease as the amount of light reaching the forest floor is reduced from shading by the overstory trees.

The **small conifer** stand condition is characterized by a closed canopy dominated by Douglas-fir in a single layer and sparse ground cover because little light reaches the forest floor. This stand condition can last from about age 35 to 75. As tree densities continue to increase, stands slowly begin to thin themselves, in a process called "self thinning" as slower-growing trees die from suppression. The majority of the snags developed and logs added to the forest floor, therefore, are small. Trees growing under these crowded conditions will eventually develop relatively slender boles and small crowns. These trees are vulnerable to damage from breakage and windthrow, especially if an adjacent stand is harvested. Thinning also increases the windfirmness of the residual stand. Normally, many of the trees removed in thinnings are those which would have become the source of small snags and small logs. Thinning greatly promotes the development of understory vegetation.

In the **mature** stand condition, which usually begins at about age 75, the average diameter of the conifer trees, usually Douglas-fir, is 21 inches or larger. The overstory canopy has opened enough to allow some development of the understory. In intensively

[7]Derived from GAP analysis GIS data. Map scale 1.250,000.
[8]Based on a combination of information from SRI (1990) and personal analysis. Time permitting, a more quantitative analysis will be completed

managed stands, tree diameters may approach those in some old-growth stands. But unless specifically managed for, the number of large snags and down logs in these stands is comparatively low. Natural stands in this condition may have nearly as much standing and down wood as is found in an old-growth stand.

Stands in the **old-growth/mature** condition are characterized by large-diameter overstory Douglas-fir trees, dying live trees, snags, abundant snags and down wood on the forest floor, replacement of Douglas-fir by shade-tolerant climax species such as western hemlock or western redcedar in canopy gaps. Stands often have multiple-layered canopies.

Because of various disturbances and lack of conifer regeneration, some stands may be partly or totally dominated by hardwoods. These stands are referred to as **mixed conifer/hardwood** or **hardwood**. Red alder is the typical dominant species in these stands, with Douglas-fir occurring as a minor component in many stands. Red alder is a relatively short-lived tree, seldom attaining an age of more than 100 years, and alder stands generally maturing at age 60 to 70 (Worthington et al. 1962). Alder stands usually have a dense shrub understory which often dominates these sites as the aging alder canopy begins to disintegrate. Douglas-fir cannot survive for extended periods under a dense alder canopy, so Douglas-fir seedlings persisting in these stands are rare. Shade-tolerant species such as western hemlock and western redcedar, however, can persits underneath the canopy (Harrington et al. 1994).

Stand condition in the watershed area is shown in Table 3.6, Map 3-6, and Appendix 8. For the watershed as a whole, about 3 percent is in the mature structural stage. Although mature/old growth timber has not been separated out in this table, it is unlikely that any significant portion of these stands are in old growth timber (older than 130 years). The majority of mature timber is located in headwater reaches, although small fragmented stands are distributed lower in the watershed. Younger structural stages dominate forests in the watershed, comprising 40% of total watershed area. The majority (21%) of these stands are in the sapling/pole and small tree stages, having been harvested 20 to 60 years ago. A large portion of the watershed is either cleared or in hardwood. Such stands are concentrated adjacent to non-forest land.

The distribution of BLM stand types is given in Table 3.7 and Map 3-7. Comparison of these age classes with structural classes for the basin as a whole indicate that past BLM timber harvest practices were similar to those for other ownerships. A total of 192 acres (3%) of BLM lands are in mature stand stage, of which no appreciable fraction is in old growth. 5,704 acres (91%) is between 30 and 80 years of age, which would fall within the sapling/pole and small tree age classes. Of this total, 4,802 acres (72% of BLM holdings) of this timber were harvested between 60 and 80 years ago, indicating that a large proportion of BLM holdings is due to enter the mature stage classes within the next 20 years. Age characteristics of Riparian Reserves are similar to those of other allocations, although the Reserves are likely to have a disproportionate amount of hardwoods.

Timber stands in headwater reaches typically consist of large patches of even-aged stands. Average patch size decreases lower in the watershed, and near major streams. Much of this fragmentation is between forest and non-forest land, and reflects ownership patterns within the watershed.

3.2.1.2 Exotic/Noxious Plants

Exotic weeds have become established within both agricultural and forested regions of the watershed. Such species tend to outcompete native species, resulting in diminished populations of these species and reduced diversity. They tend to be aggressive colonizers on disturbed soils, and typically are found in fields, waysides, and other ruderal habitats. Eradication of these exotics is often difficult. In the Dairy-McKay watershed, common exotic plant pest species include Himalayan blackberry (*Rubus procerus*), reed canarygrass (*Phalaris arundinacea*), Scotch broom (*Cytisus scoparius*), and various species of thistle.

In 1998, a weed survey was performed by BLM. Five species got special scrutiny. These included Scotch broom, blackberry, reed canarygrass, bull thistle, and Canada thistle. Roadsides and other disturbed sites were selected for surveys (Chevron et al. 1998). Surveyors found that Himalayan blackberries were nearly universal at survey sites. Reed canarygrass was also abundant, particularly in riparian areas. Scotch broom was also commonly found. Due to the difficulty of manual eradication methods, chemical methods were recommended for most species. Additionally, researchers concluded that the invasiveness of these species and the fragmented ownership of the watershed required that partnerships be generated between landowners to eradicate these exotics.

In agricultural areas, certain exotic species are determined to be toxic to livestock, or otherwise have a substantial detrimental effect to agricultural

Table 3-6. Size classes of forested lands on all ownerships

Size class (inches)	Age class	Total area (acres)	percent of watershed
0 to 9		26,811.35	19.4%
10 to 20		28,603.77	20.7%
21 to 30	>80	4,205.44	3.0%
over 30		0.23	0.0%
urban/agriculture		78,744.57	56.9%
other nonforested		94.98	0.1%
Total		138,460.34	100%

Table 3-7. Age classes of forest on BLM lands

	Total area (acres)		Percent of allocation	
Age Class (years)	Riparian Reserves	Other	Riparian Reserve	Other
0 to 20	179.00	189.00	6%	6%
30 to 50	388.00	514.00	12%	16%
60 to 80	2,429.00	2,373.00	77%	75%
90 to 110	135.00	57.00	4%	2%
nonforested	35.00	27.00	1%	1%
Total	3,166.00	3,160.00	100%	100%

operations. Such plants are designated by the Oregon Department of Agriculture (ODA) as noxious weeds. A list of ODA noxious weeds is given in Appendix 9. Listed weeds of particular concern in the Dairy-McKay watershed include Scotch broom (*Cytisus scoparius*), tansy ragwort (*Senecio jacobaea*), and spotted knotweed (*Polygonum sp.*). Although gorse (*Ulex europaeus*) has not been found in Washington County, patches have been found in Columbia, Tillamook, and Clackamas counties. As gorse is an ODA Target (priority) noxious weed, any sightings should be brought to the attention of ODA personnel.

Several species may be added to the ODA noxious weed list in the near future. These include nursery plants such as giant reed (*Arundo donax*), and Pampas grass (*Cortaderia selloana*). These species have proved invasive in California, and are currently to be reviewed for the potential for similar problems in Oregon.

Current ODA financing for abatement of noxious weeds is limited. However, financing requests before the Oregon Legislature would provide for funds to finance counties for special weed abatement projects and provide cost-share assistance to private landowners.

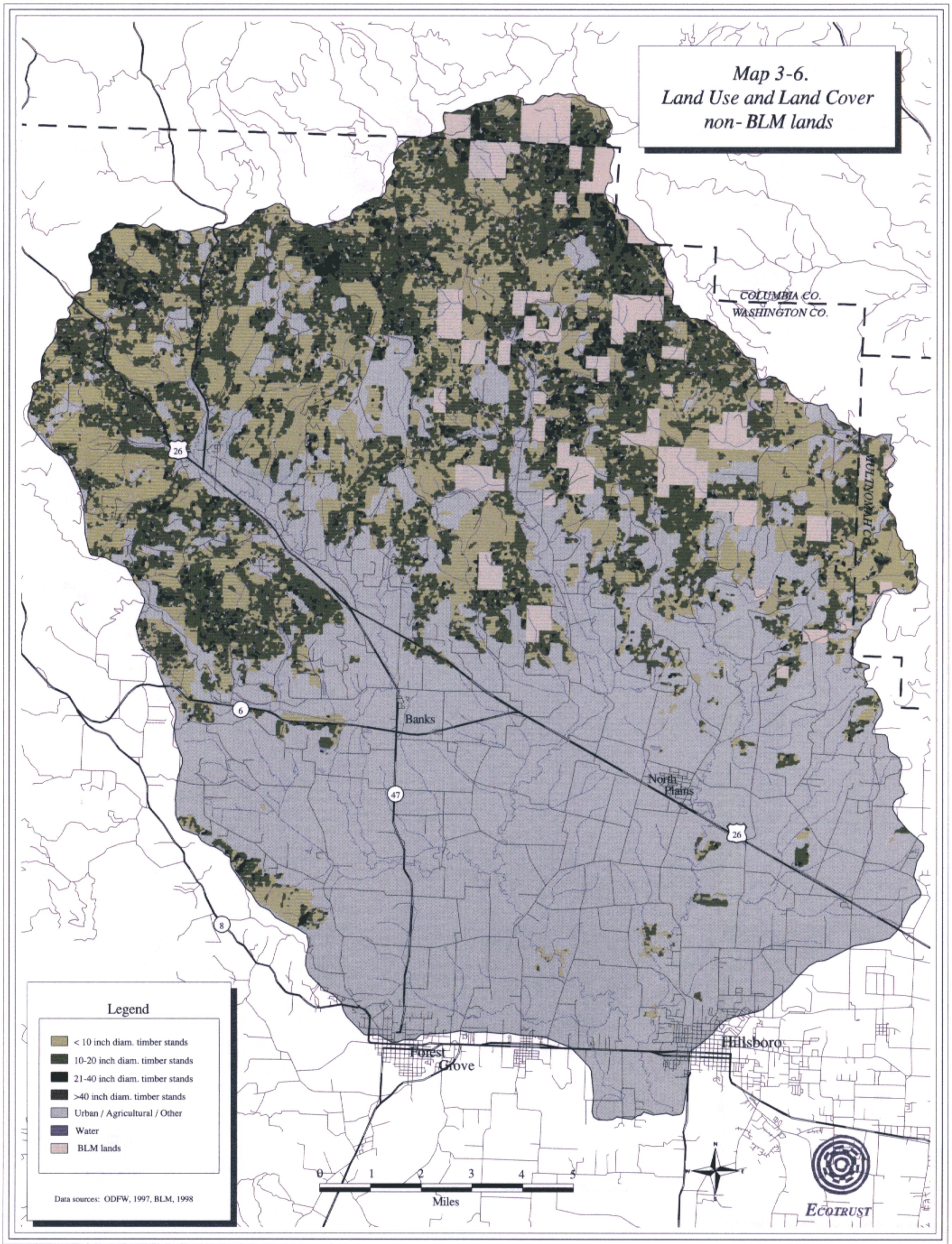
3.2.2 Species and habitat

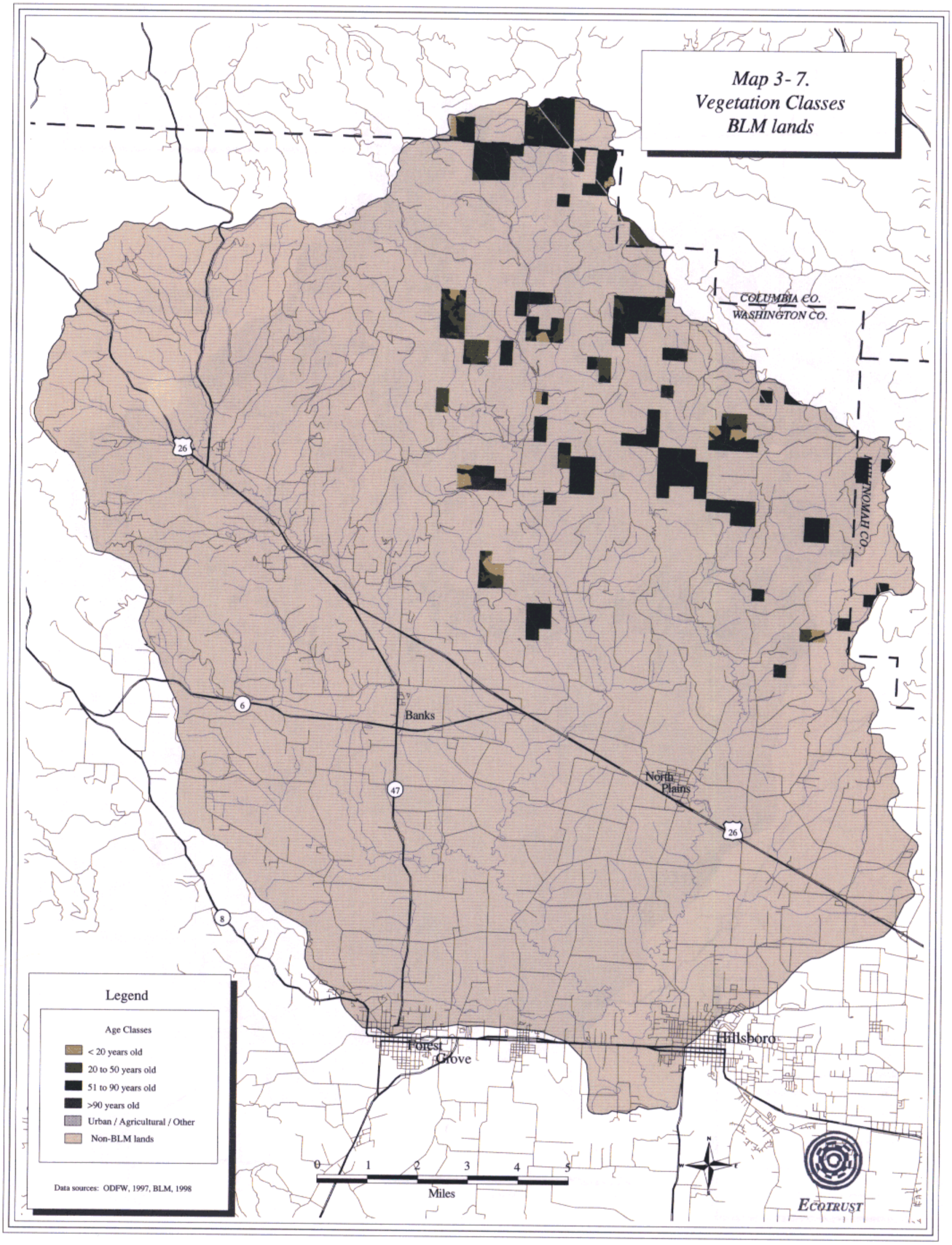
3.2.2.1 Abundance and habitat of terrestrial species

3.2.2.1.1 Economically important species

Game hunting is popular in the watershed. Popular big game species include Roosevelt elk, black-tailed deer, and black bear. Most big game hunting in the watershed occurs in the Tualatin Mountains. Principal big game areas include the West Fork above Manning, the East Fork above Meacham Corner, and McKay Creek above Kay Road (ODEQ and USA 1982).

Roosevelt Elk (*Cervus elaphus roosevelti*)
Like most of western Oregon, Roosevelt elk is an important game animal within the watershed. Elk


Map 3-6.
Land Use and Land Cover
non- BLM lands
COLUMBIA CO.
WASHINGTON CO.
MULTNOMAH CO.
26
6
Banks
47
North Plains
26
8
Forest Grove
Hillsboro
Legend
< 10 inch diam. timber stands
10-20 inch diam. timber stands
21-40 inch diam. timber stands
>40 inch diam. timber stands
Urban / Agricultural / Other
Water
BLM lands
Data sources: ODFW, 1997, BLM, 1998
0 1 2 3 4 5
Miles
ECOTRUST



Map 3-7.
Vegetation Classes
BLM lands
COLUMBIA CO.
WASHINGTON CO.
MULTNOMAH CO.
26
6
47
8
Banks
North Plains
Forest Grove
Hillsboro
Legend
Age Classes
< 20 years old
20 to 50 years old
51 to 90 years old
>90 years old
Urban / Agricultural / Other
Non-BLM lands
Data sources: ODFW, 1997, BLM, 1998
0
1
2
3
4
5
Miles
ECOTRUST

populations appear to be stable to slightly increasing (Tom Thornton, ODFW, personal communication). The abundance and distribution of Roosevelt Elk within an area is generally dependent on the amount of forage and cover and their distribution in time and space. BLM's checkerboard land ownership pattern within the watershed benefits elk as the differences in management strategies between the BLM and private landowners commonly result in the juxtaposition of cover and open foraging areas. The high level of timber harvest on private land over the last decade has resulted in increased forage availability for elk, although in some areas the large expanses of clearcuts may have eliminated needed cover. The current pattern can potentially result in an uneven distribution of elk and increased potential for conflicts resulting from animal damage. Elk populations in the Dairy-McKay watershed do not appear to be creating a substantial conflict with human interests (Thornton, personal communication).

3.2.2.1.2 Special status species

3.2.2.1.2.1 Botanical Species

A list of special attention plant species potentially found in the Dairy-McKay Creek watershed is given in Table 1-3. Additionally, several Survey and Manage fungi and lichen species have been observed in the Dairy-McKay watershed (Table 3.8). These include:

Lobaria pulmonaria, a lichen, which was found near the East Fork Dairy Creek, north of Mountaindale. This plant falls within BLM Survey & Manage Category 4, the objective of which is to "survey to determine necessary levels of protection and to acquire additional information about the species" (BLM 1995).

Helvella compressa, a Survey and Manage Category 1 and 3 mushroom. This mushroom was found on BLM land adjoining Wirtz Creek in the East Fork Dairy-McKay watershed (T2N, R3W, S21).

Watch listed plant species, (that is, BLM tracking species, as defined within BLM manual 6840) that have been found on BLM land within the watershed include The western wahoo (*Euonymus occidentalis*). This species was found in the BLM parcel at Wirtz Creek (T2N, R3W, S21, SE 1/2). Knowledge about "Tracking species" enables an early warning for species that may become threatened or endangered in the future. Districts are encouraged to collect occurrence data on species for which more information is needed.

In the Dairy-McKay watershed, special habitats for sensitive species are found both on BLM and private lands. These include wetlands[9]. The values for wetland habitats are especially important because they are a critical source of biological diversity. These habitats include the relatively large wetlands in the Tualatin Plain, as well as small ponds in the mountains. One such pond habitat is located near the headwaters of the East Fork Dairy Creek (T4N, R3WS, 32, NE1/4 of SW1/4). These habitats are fragile and comprise an extremely small percentage of the public lands administered by the BLM. Wetland habitat protection is featured in BLM programs[10]. Another sensitive habitat for botanical species is the Big Canyon Late Successional Reserve (LSR), which is located on BLM land (T2N, R3W, S5, South 1/2). According to the Salem District Record of Decision and Resource Management Plan, the objective for the designation of LSR's is to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth forest-related species. The purpose is to maintain a functional, interacting, late-successional and old-growth forest ecosystem. A plant zone vegetation survey of the Big Canyon area was conducted in 1989.

3.2.2.1.2.2 Amphibians

Clouded salamander (*Aneides ferreus)* (BS)

Clouded salamanders are terrestrial amphibians that inhabit large decaying logs, stumps, and snags. Although their presence has not been verified, it is very likely they occur within the watershed. Current management strategies on private lands involve short timber harvest rotations, which could preclude the long-term maintenance and/or development of habitat for clouded salamanders on these lands. Management of federal lands within the Dairy-McKay watershed provides for development of late-successional habitat within Riparian Reserve and Late Successional Reserve allocations. Current timber harvest standards and guidelines mandate retention of green trees, snags, and down wood. These policies should provide for the long-term maintenance and/or development of habitat for clouded salamanders on federal lands.

[9]For BLM management purposes, wetland habitats are defined by BLM Manual 6740.
[10](FLPMA- Section 102(a)(8) &(11) and enhancement planning Executive Order 11990)

Table 3 8 Survey and Manage fungi and lichen species found in the Dairy-McKay Creek watershed.

Species	Type	Survey and Manage strategy
	Fungi	
Cantherellus formosus	Chanterelle	3,4
Cantherellus tubaeformis	Chanterelle	3,4
Clavulina cristata	Branched coral fungi	3,4
Cudonia monticola	Rare resupinates and polypores	3
Helvella compressa	Rare cup fungi	1,3
Phytoconis ericetorum	Mushroom lichen	3,4
	Lichens	
Lobaria pulmonaria	Nitrogen-fixing lichen	4

3.2.2.1.2.3 Birds

Northern saw-whet owl (*Aegolius acadius*) (BA) These small owls are known to occur within the watershed.

Marbled murrelet (*Brachyramphus marmoratus*) (FT) Habitat. The Dairy-McKay watershed lies in a band which is from 32 to 51 miles from the ocean, mostly within Marbled Murrelet Zone 2 as identified in the FEMAT report (FEMAT 1993). There is no designated critical habitat within the watershed.

Based upon stand ages, approximately 3% of the watershed (4,206 acres) has potential to be suitable marbled murrelet habitat. The majority of this potentially suitable habitat (94%) is on private land, with the remaining 6% (254 acres) being managed by the BLM[11]. Given that industrial timber companies tend to manage on an economic rotation, it is probably safe to assume that most of the potentially suitable murrelet habitat on private land will be harvested within the next 10 years. The majority of federal habitat acres are located on lands allocated as LSR or Riparian Reserves. The largest single block of suitable land is within the Big Canyon LSR.

Potentially suitable habitat is scattered throughout the forested portion of the watershed. Much of this habitat is fragmented, existing in small patches. However, large blocks of potential habitat are centered in headwater reaches within the watershed. Subwatersheds containing such large blocks include the Upper West Fork, Williams Creek, Mendenhall Creek, Whitcher Creek, East Fork Dairy Creek headwaters, and Upper McKay Creek.

The amount of annual rainfall within the watershed (38-65 inches) is considerably less than the amounts received in coastal areas, resulting in less moss accumulation and probably a decreased potential (or longer time necessary) for the development of future murrelet habitat. Management of federal lands in LSR, Riparian Reserve and Connectivity land allocations should favor the development of murrelet habitat on these lands. The intensive management on private lands is expected to preclude the development of murrelet habitat.

Sites – There are no known, occupied or historical marbled murrelet sites within the watershed. The greatest likelihood for murrelet sites would be along the western headwaters of the watershed.

[11]This assumes that most murrelet habitat will be found in structurally mature forest, the extent of which has been determined by calculating watershed area with stands exceeding 21" (all lands) or greater than 80 years age (BLM).

Northern spotted owl (*Strix occidentalis*) (FT)

The spotted owl population within the Oregon Coast Range Province is extremely low and in a significant decline (The Draft Recovery Plan for the Northern Spotted Owl – 1991). Designated as an Area of Concern for recovery of the spotted owl by the US Fish and Wildlife Service (USFWS), this is especially true for the northern portion of the Coast Range Province where habitat is severely limited and poorly distributed. Although the Dairy-McKay watershed is located east of the Coast Range summit and therefore actually in the Willamette Physiographic Province, the situation for spotted owls within the watershed is just as poor. There is commonly a substantial distance between areas of suitable habitat, which may not be in a condition to facilitate dispersal. This general lack of suitable and dispersal habitat within the watershed (especially on private lands) results in localized isolation, which coupled with the larger regional isolation greatly reduces the prospect for owl recovery in the portion of the state containing the Dairy-McKay watershed.

Habitat – The Dairy-McKay watershed contains no spotted owl designated critical habitat.

In general the spotted owl habitat in and around the Dairy-McKay watershed is very poor; it is very highly fragmented and uniformly young; only approximately 7% of the forested stands within the watershed (4,206 acres) are older than 80 years. An undetermined but far smaller portion is older than 130 years. Additionally, large barriers to dispersal, (blocks of non-habitat less than 20 years old, and from 0.5 to 1.5 or more square miles in size) are not uncommon across the landscape.

Sites - There were formerly two spotted owl sites on BLM land in the watershed. One was in Denny Whiskey (T3N, R3W, S19), and the other at Big Canyon (T3N, R3W, S5). Owls were last sighted at these locations in 1978. Visits in 1991, 1992, and 1993 failed to detect owl activity at these sites. Due to the lack of unfragmented late successional habitat, spotted owls are no longer considered viable within the watershed.

Portions of the Dairy-McKay watershed have been surveyed between 1991 and 1993 in conjunction with the timber sale program. These surveys resulted in no owl detections within the watershed. Relatively recent surveys conducted within an adjoining watershed (East Fork of the Nehalem) resulted in two spotted owl detections, the first spotted owls located in the area in a decade or more. Neither birds were relocated during follow-up visits which coupled with the habitat condition within the area may suggest they were transient or dispersing birds.

Northern bald eagle (*Haliaeetus leucocephalus*) (FT)

Sites- Although bald eagles may occasionally be observed within the watershed, there are no known nests within the watershed.

Habitat- Current management strategies on private lands involving short timber harvest rotations, could preclude the development of habitat for bald eagles on these lands. Management of federal lands within the Dairy-McKay watershed given the Northwest Forest Plan's land allocations (LSR, Riparian Reserve, and Connectivity) and Standards and Guidelines could provide for some long-term benefit to bald eagles. The long-term benefits to eagles resulting from federal management practices may include the improvement of foraging opportunities as salmonid stocks of concern improve or the development of roosting and nesting habitat on federal lands. The actual significance of these potential benefits is questionable given the small percentage of federal ownership within the watershed and larger landscape.

Pileated woodpecker (*Dryocopus pileatus*) (BA)

Pileated woodpeckers are dependent on some components of older forests such as large snags for drumming, roosting, nesting and foraging and a good supply of large snags and down wood for foraging. These woodpeckers are often observed foraging in young stands or even clearcuts if large stumps, snags or down wood are present. Current management strategies on the majority of private lands involve shorter timber harvest rotations, which could preclude the maintenance or development of habitat for pileated woodpeckers on these lands and potentially lead to local extinction. Management of federal lands within the Dairy-McKay watershed given the Northwest Forest Plan's land allocations (LSR, Riparian Reserve and Connectivity) and Standards and Guidelines (green tree, snag and down wood retention) should provide for some long-term benefit to pileated woodpeckers. These long-term benefits include the improvement of foraging and nesting habitat on federal lands.

3.2.2.1.2.4 Mammals

Red tree vole (*Phenacomys longicaudus*) (S&M)

The red tree vole is a category 2 species under the S&M strategy (survey prior to activities and manage known sites). Being nocturnal and spending most of its life in the canopy of large coniferous trees, it is a difficult species to study. Consequently, abundance, habitat associations and population ecology of the species is not well understood. They are strongly associated with older forests and being poor dispersers are very vulnerable to local extinctions resulting from habitat loss and fragmentation. They require larger blocks of contiguous habitat or corridors connecting areas of suitable habitat; in the Oregon Coast Range, the mean stand size used by tree voles is 475 acres (75 acre minimum) (Maser 1981; Huff, Holthausen and Aubry 1992). The red tree vole is a species which has been identified as significantly benefiting from the Northwest Forest Plan's riparian reserve network to provide connectivity (USDA, USDI 1994). Although they have been found in stands as young as 62 years old, it is thought, depending upon individual stand characteristics, that stands younger than 100 years old are unable to maintain viable populations (Carey 1991).

The Dairy-McKay watershed is on the edge of their range; some sources show the watershed as being outside their range (Carey 1991). Regardless, given the fragmented nature of the Dairy-McKay watershed and the fact that a low proportion of forest stands are older than 80, the red tree vole certainly is likely to be very rare within the watershed, if it hasn't already been extirpated. The stands which have the highest potential of being occupied by red tree voles are located in headwaters reaches of the watershed. There are thought to be no stands of mature timber on BLM lands of sufficient size to maintain a vole population.

Current management strategies on the majority of private lands within and adjacent to the watershed involve shorter timber harvest rotations. This will preclude the development of habitat for red tree voles on these lands. Management of federal lands within the Dairy-McKay watershed, given the Northwest Forest Plan's land allocations (LSR, Riparian Reserve and Connectivity) and Standards and Guidelines, should provide for some long-term benefits to red tree voles. These benefits may include improved connectivity and the development or improvement of habitat on federal lands. However, several factors work against the increase of vole populations within the watershed:

- the vole's poor dispersal capability;
- the current ownership pattern;
- the high potential that they are extirpated from much if not all of the Dairy-McKay watershed and surrounding watersheds.

As suitable habitat develops natural recolonization of the watershed may be difficult for this species.

Survey and Manage Bats

One of the leading factors in the decline of worldwide bat populations is the destruction of roost sites and hibernacula. Most bat species occurring in the Pacific Northwest roost, reproduce, and hibernate in protected crevices that fall within a narrow range of temperature and moisture conditions. There is a strong concern that the loss of snags and decadent trees from the widespread conversion of old-growth forests to young, even-aged plantations, human disturbance and destruction of caves and mines, old wooden bridges and buildings have significantly reduced the availability of potential roost sites.

There are four "Survey and Manage" bat species that may occur within the Dairy-McKay watershed. All four species are associated with coniferous forests and forage primarily over riparian zones, especially over streams and ponds in proximity to roosting habitat. There is little or no information concerning the population health or distribution of these species within the watershed. However, based upon the low abundance of suitable roosts they are expected to be present in low numbers or even absent from the watershed. All are category 2 species under the S&M strategy (survey prior to activities and manage known sites). To date, (February 1999) no surveys have been conducted within the watershed to determine the presence of Survey and Manage bats. There are no known sites within the watershed although there are a few specific areas that seem to have potential for occupancy.

Long-eared myotis (*Myotis evotis*), Fringed myotis (*Myotis thysanoides*) and Long-legged myotis (*Myotis volans*)

These three S&M species potentially found in the Dairy-McKay watershed are small nonmigratory, crevice-roosting bats with widespread distributions that use snags, decadent trees, buildings, bridges and caves for roosting and hibernating. All three are also identified as Bureau Sensitive (BS) under BLM Special Status Species Policy.

Silver-haired bat (*Lasionycteris noctivagans*)

The silver-haired bat is a relatively large, migratory, widely-distributed snag and decadent tree-roosting bat, although it may occasionally use buildings and caves for roosting.

3.2.2.2 Effect of ownership upon habitat management opportunities

Successful habitat management depends upon cooperation between landowners. However, most of the watershed is owned by private non-industrial sources. The presence of many owners and, in many cases, small parcels, leads to a fragmentation of ownership and habitat that complicates management efforts.

Industrial landowners may present opportunities for cooperative habitat management efforts. The largest contiguous forest parcels are within such ownerships. Success of cooperative efforts with industrial landowners relies upon tailoring of habitat management plans that are consistent with industrial operations.

3.2.2.3 Current distribution and density of snags and down wood

Snags and down wood are characteristically produced by forest stands in mature/old-growth condition. Few, if any, of the timber stands in the Dairy-McKay watershed are in this condition. Additionally, most forested acreage was logged under practices that discouraged snag retention. Thus, snag incidence within the watershed is expected to be correspondingly low.

As with the rest of the watershed, lands managed by BLM have low snag densities. One notable exception is at the Big Canyon LSR, where many snags have been observed. Down wood also appears to be abundant in this parcel. Present federal timber harvest practices promote retention of snags and down wood, so abundance of these habitat elements is expected to improve in the future.

3.2.3 Forest resources

3.2.3.1 Forest productivity, diseases, and other pathogens

Laminated root rot, caused by the fungus *Phellinus weirii*, is widespread and has a major influence on the character of many Douglas-fir stands in the watershed. *P. weirii* readily infects and kills highly susceptible conifer species such as Douglas-fir and grand fir. Western hemlock is considered intermediately susceptible and western redcedar is thought to be resistant to the disease (Hadfield 1985). All hardwood species are immune. Tree-to-tree spread is through root contacts with infected roots or stumps (Hadfield et al. 1986). Affected trees are often windthrown when their decayed root systems are no longer able to provide adequate support (Thies 1984). Other trees often die standing. Douglas-fir beetles often attack and kill infected trees weakened by the disease. This disease, therefore, is a major source of snags and down wood.

P. weirii infection centers often appear as openings in the forest containing windthrown, standing dead, and live symptomatic trees, along with a relatively well-developed shrub layer (Hadfield 1985). Centers may also contain hardwoods and less-susceptible conifers. Disease centers range in size from less than one acre to several acres in size. Centers expand radially at the rate of about one foot per year. Douglas-fir timber productivity levels in *P. weirii* infections centers are generally less than one-half of those in uninfected areas (Goheen and Goheen 1988). Timber losses in diseased stands may double every 15 years (Nelson et al. 1981). High levels of *P. weirii* infection (>25 percent of the area infected) generally preclude commercial thinnings in Douglas-fir stands, especially if disease centers are not well defined.

Insects also have the potential to threaten the health of forest stands. The Douglas-fir bark beetle, *Dendroctonus pseudotsugae*, causes most of the insect damage in the Dairy-McKay watershed. This beetle typically attacks trees that have been weakened by other factors (BLM and USDA Forest Service1997). Beetle infestations may reach levels of concern at sites where large amounts of dead wood are present.

3.2.3.2 Late Successional Reserves/ Big Canyon

In developing a conservation strategy for late-successional forest-associated species, the Northwest Forest Plan designated a network of Late-Successional Reserves (LSR's) across the Pacific Northwest. This reserve network is designed to protect habitat for late-successional forest species where habitat conditions are relatively intact, and to promote the development of late-successional forest habitat conditions where such habitat is limited, and the associated plant and wildlife populations are low. Over the next 50 to 100 years, populations of late-successional forest species are expected to stabilize within the larger LSR blocks and eventually increase in response to improving habitat conditions. Populations of late-successional forest species outside of the reserves are expected to decrease over time and may eventually disappear.

The only LSR within the Dairy-McKay watershed is located at Big Canyon, which drains to the East Fork of Dairy Creek. This parcel comprises 280 acres, or 0.2% of total watershed area. As there are no other LSR's nearby, Big Canyon is not expected to provide connectivity for species with large home range relying on late-successional habitat. However, within the watershed, it provides unique habitat for species with small home ranges. Additionally, the relative abundance of snags and down wood in Big Canyon potentially provides roosting habitats for bats. The Big Canyon LSR also contributes toward federal objectives for late-successional forest. According to these objectives, at least 15% of federal lands within the Dairy-McKay watershed should be maintained in late-successional vegetation (BLM 1995). Presently, less than half of the acreage in the Big Canyon LSR is in late-successional habitat. Within the next twenty years, about 80% of the LSR should develop late-successional characteristics, as timber stands currently in small-conifer stage advance to the mature conifer stand condition.

3.3 SOCIAL

3.3.1 Human uses

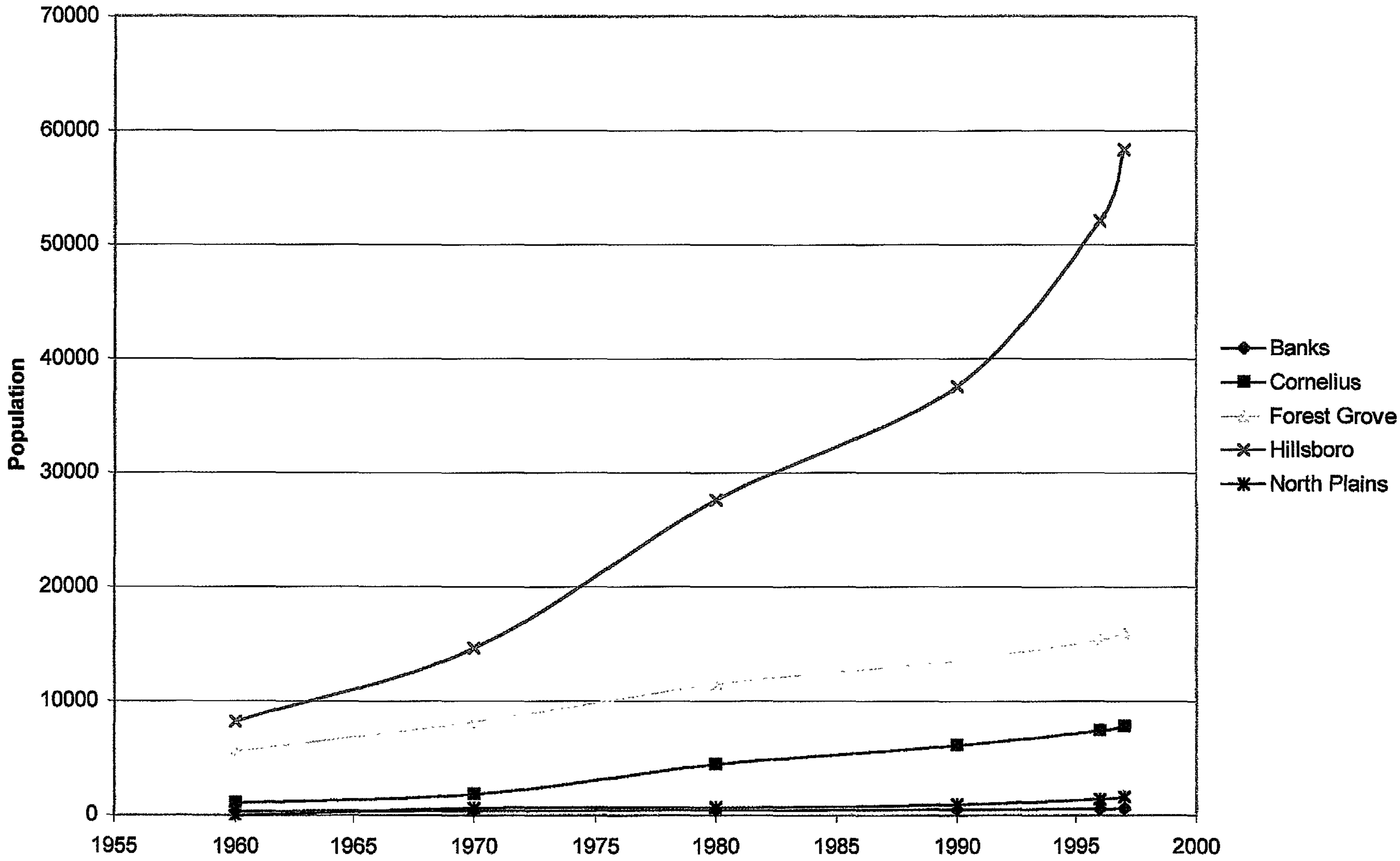
3.3.1.1 Economic Uses

3.3.1.1.1 Urban

Washington County is the fastest growing county in Oregon in terms of population. Rapid growth has characterized Washington County throughout the latter half of the 20th Century (Figure 3-1). Between 1960 and 1997, county population grew by 317%. Although much of the early growth was concentrated to the east of the watershed, Hillsboro's growth rate met or exceeded the county as a whole throughout this period. With the growth of the Portland metropolitan area, high population growth rates have characterized most cities within the Dairy-McKay watershed. Given these past trends, high future rates of growth would be anticipated in the watershed. This increase in population has placed demands upon watershed resources.

Current planning efforts emphasize infilling of the current urban growth boundary (UGB), rather than expansion. However, some expansion of the UGB is anticipated. To allow for population growth, Portland Metro has designated urban reserves that delineate

Figure 3-1. Population of Cities within the Dairy Creek Watershed, 1960-1997



priority areas for incorporation into the UGB. Currently, 30 acres in the northeastern portion of the Dairy-McKay watershed is designated as Urban Reserve. In the near future, the indication is that little expansion of urban growth will be centered within the Dairy-McKay watershed. However, growth outside the UGB may take place.

Past and future urbanization has centered around the lower watercourses of the Dairy-McKay watershed. Hillsboro lies along the lower course of Dairy and McKay creeks, while Cornelius lies beside Council Creek. Further upstream, Banks is located on the West Fork of Dairy Creek, and North Plains lies along McKay Creek. It is anticipated that impacts associated with urbanization will be focused on these streams.

3.3.1.1.2 Agriculture

Agriculture is the major economic activity of unurbanized portions of the Tualatin Plain. In 1997, the total value of crops in Washington County was estimated at $173,914,000, with livestock activities adding $14,003,000 in value (Preliminary data from OSU extension economic information office). As Dairy Creek contains about 40% of the agricultural land in Washington County, it is reasonable to believe that the watershed produces about $75,000,000 in agricultural products annually. Statistics from the 1992 agricultural census for the five zip code areas encompassing the watershed were analyzed to ascertain the characteristics of farming operations in the watershed (Table 3-9). It should be noted that these statistics are classified by number of landowners, and not total acres in production. According these records, the vast majority of farms are small, with less than 50 acres in agriculture, and gross annual sales of less than $10,000. The large number of farms with low economic production reflects a large component of part-time farming. (More than 50% of the farmers who took part in the census named a non-farm activity as their primary occupation.) Additionally, it possibly indicates low earning margins and a vulnerability to increases in operating expenses.

Hay and orchard fruits (including filberts) were the crops most commonly grown within the watershed. Production of nursery crops, wheat, and oats was also widespread. Livestock and poultry operations were common, with the majority of these operations raising cattle and calves. Pasture and grazing also were common agricultural activities.

The 1997 agricultural census summarized land area devoted to crop production for Washington County. These figures showed that the most cropland was devoted to wheat (17,020 acres), with hay (14,539 acres), orchard crops (8,403 acres), and vegetable production (8,167 acres) being the most widespread crops. Wheat and vegetables tended to be grown on relatively large farms, with mean plot sizes of 85 and 66 acres, respectively. Hay and orchard crops were typically raised on smaller farms. Twice as many farmers raised these crops as raised wheat, but mean plot sizes for hay and orchard crops averaged 33 and 18 acres, respectively. Although similar information was not summarized for the Dairy-McKay watershed, it is likely that farm characteristics in the watershed would be similar to those for Washington County as a whole.

3.3.1.1.3 Forestry

Forestry is the dominant land use in the Tualatin Mountains. Thirty-eight percent of the land is industrial forest, of which Longview Fibre is the largest landowner. Between 1990 and 1995, 606,687 thousand board feet of timber were cut in Washington County. Of this total 64% (390,106 thousand board feet) were cut on private industrial lands. Over this period, the trend has been for increasing timber harvest as forests reach merchantable age (Figure 3-2).

The effect on local employment of increased harvest in the watershed is uncertain. Between 1996 and 2006, the Oregon Employment Department projects a 17% increase in employment in the agricultural and forestry sectors in Washington and Multnomah counties (OED 1998). However, the OED also expects employment demand for several timber-related positions to decline over the same period. In the two-county region, manufacturing related to lumber registered a slight decline between 1997 and 1998.

3.3.1.1.4 Mining

The most important mineral resources within the watershed are sand, gravel, and crushed rock. Sand and gravel are commonly mined from streams, while basalt is mined to obtain crushed rock. These materials are commonly used for construction and road maintenance. Important rock pits include the Pacific Rock Products pit located in the McKay Creek subwatershed near the confluence with Dixie Mountain Road, the Van Aken pit in the Sadd Creek subwatershed and the Washington County pit near Jackson Creek. Additionally, smaller pits associated with road-building operations are distributed elsewhere in the watershed.

Table 3-9. Agricultural statistics for farms in the five zip codes surrounding and including the Dairy Creek watershed.
Source: Oregon Agricultural Census, 1992.

	97116 Forest Grove	97113 Cornelius	97106 Banks	97109 Buxton	97124 Hillsboro	Total	Proportion in class
# Farms	184	187	101	17	407	896	100%
# , farm size less than 40 acres	112	118	67	9	301	607	68%
# , market value of agricultural products sold < $10,000	99	96	67	16	277	555	62%
#, market of agricultural products sold $10,000 to $99,999	53	56	20	1	87	217	24%
#, market value of agricultural products sold >$99,999	32	35	14	0	43	124	14%
# nurseries	18	24	7	1	62	112	13%
# dairy farms	4	8	5	0	10	27	3%
Operators, principle occupation is farming	93	95	30	4	171	393	44%
Operators, named other (non-farming) principle occupation	91	92	71	13	236	503	56%
Farms where crops were harvested	156	149	74	10	339	728	81%
Farms where cropland was used for pasture or grazing	40	50	26	6	125	247	28%
Cropland not harvested nor pastured	19	12	10	0	24	65	7%
Farms with woodland	65	80	45	10	157	357	40%
Farms with pastureland and rangeland	25	31	19	4	61	140	16%
Farms where cattle and calves were raised	51	57	34	9	149	300	33%
Farms where swine were raised	9	13	11	2	9	44	5%
Farms where sheep and lambs were raised	8	9	8	1	32	58	6%
Farms where hens and pullets were raised	15	14	6	1	29	65	7%
Farms where horses and ponies were raised	24	35	21	4	79	163	18%
Farms where corn for silage was raised	9	6	5	0	8	28	3%
Farms where wheat was raised	51	43	21	0	43	158	18%
Farms where barley was raised	5	5	2	0	3	15	2%
Farms where oats were raised	22	28	15	1	37	103	11%
Farms where land was used for hay production	48	64	39	7	127	285	32%
Farms where vegetables were produced for economic purposes	31	18	5	1	34	89	10%
Farms with orchards	64	40	29	1	145	279	31%
Farms where berries were produced for economic purposes	23	27	8	1	42	101	11%

Extensive bauxite deposits exist in the lateritic soils of the Columbia River basalt areas. Formerly several mining claims existed in the watershed, but development of these bauxite deposits never became economically feasible, and these mining claims are inactive.

3.3.1.1.5 Conflicts between BLM and the public

In the Dairy-McKay watershed there are potential and existing conflicts between public use and federal land management activities. Illegal dumping is a widespread problem on lands of all ownerships, including BLM-managed lands. Most dumping occurs at locations that are easily accessible by roads. A campground (day use area) adjacent to Dairy Creek Road at Little Bend was closed down because of vandalism and dumping problems.

In order to counter dumping and vandalism, and to minimize fire danger, private industrial landowners such as Longview Fibre have adopted a closed gate policy on their roads. Most BLM roads linked to county roads are accessible to the public. However, many of these roads have been closed by landslides.

In several areas, BLM activities could present a potential conflict with rural residential activities. Several BLM parcels near Jackson Creek lie within 1/4 mile of land within a rural residential 5 acre zoning. This range was determined by the Salem ROD as a criterion for determining potential rural interface problems. These sites also have been determined to have potential visual impact problems. Other parcels are located near rural population concentrations along East Fork Dairy Creek.

3.3.1.2 Recreational opportunities

Recreational opportunities vary between urban and rural portions of the watershed. Urban areas typically have developed recreation opportunities, both indoor and outdoor. Indoor recreation is considered to impose the same types of demands and impacts on watershed resources and are not considered here. Outdoor activities include parks and golf courses.

Four golf courses are located in the watershed. McKay Creek golf course is in western Hillsboro, while Pumpkin Ridge golf course is near North Plains. Two other courses, Quail Valley and Sunset Grove, are located between Banks and Forest Grove. Demands upon watershed resources depend upon the extent to which recycled wastewater is used for watering golf courses. There is also potential for these courses to introduce fertilizers to runoff.

A glider site is located off of Dersham Road near Mountaindale. No known impacts exist for this site.

Recreation further from urbanized areas is typically dispersed. Such activities include nonconsumptive activities such as walking, jogging, and wildlife viewing. These activities should generally offer low impacts, although there is potential for wildlife disturbance and localized soil compaction. Additionally, the scenery of the area offers opportunities for pleasure driving. This activity places the same demands and risks upon the watershed as other driving activities. BLM lands offer limited potential for these activities.

Consumptive recreation includes hunting, fishing, and mushroom collecting. The Tualatin Mountains offer seasonal opportunities for hunting of Roosevelt elk and blacktailed deer. Small game species and waterfowl are also hunted.

BLM lands afford limited opportunities for both nonconsumptive and consumptive activities. Access considerations limit many of these opportunities, although the parcel off of Uble Road provides opportunities for hiking and horseback riding. BLM lands lie within potentially good hunting areas for elk and deer, and parcels with stream access afford fishing for cutthroat trout. There once was a campground at Little Bend, but it was shut down due to vandalism.

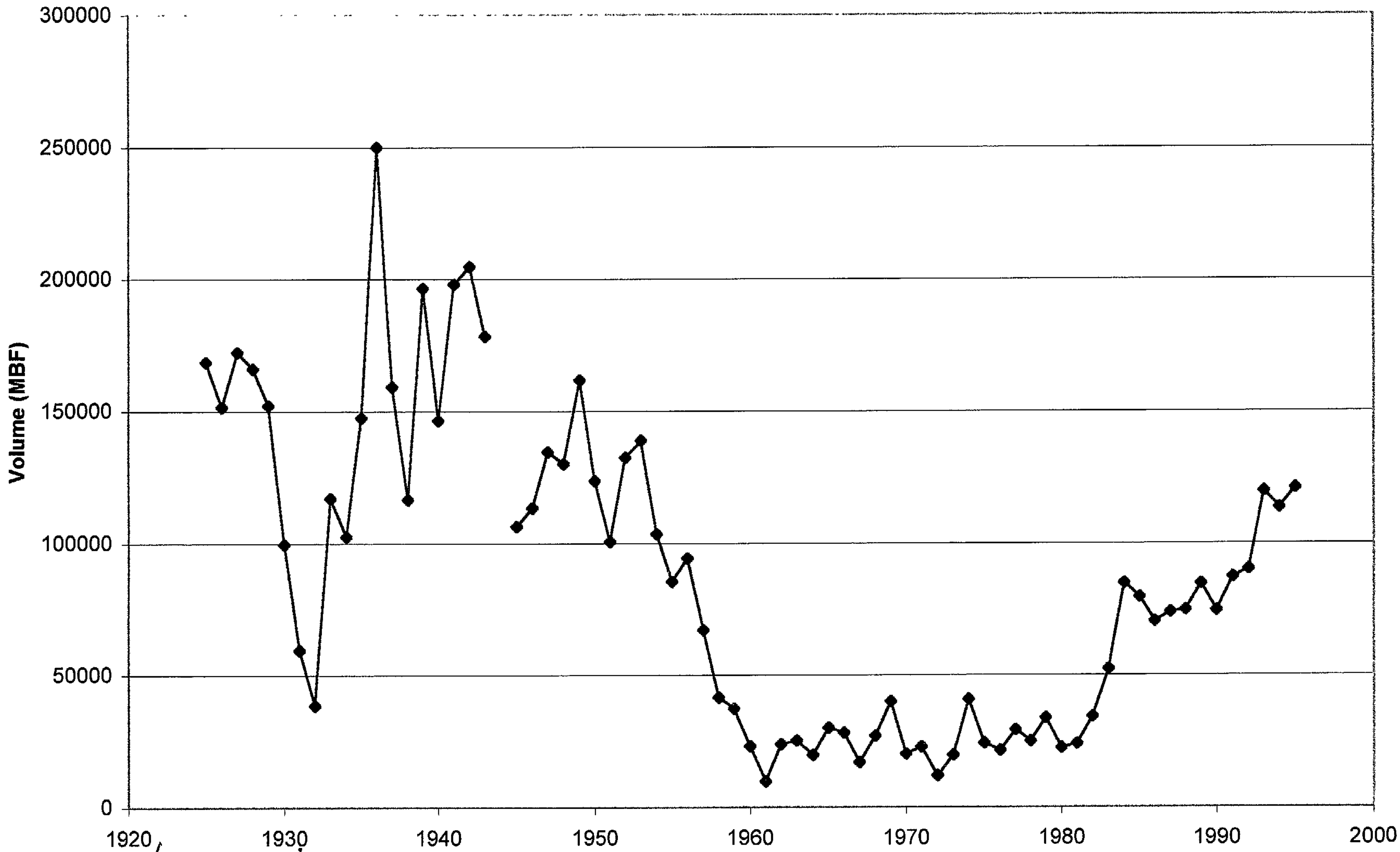
3.3.1.3 Cultural Resources

Native Americans of the Tuality Tribe were known to occupy portions of the watershed near the Wapato swamp and near North Plains (BLM 1979). Two Oregon tribal governments (the Confederated Tribes of Grande Ronde and Confederated Tribes of Siletz) were notified to identify the location of any cultural resources related to traditional or historical use within the watershed. To date, no cultural resources of concern have been identified.

3.3.2 Roads

The vast majority of timberlands within the Dairy-McKay watershed have been logged since 1920. In connection with this logging, extensive road construction would have ensued. In the early part of the century, this would have consisted of railroad grades, which gave way to extensive construction of truck roads as the century progressed.

Washington County Timber Harvest, 1925-1995



Source: odf annual reports

There are an estimated 999.53 miles of roads within the Dairy-McKay watershed, of which 31.27 miles (3.1%) occur on BLM lands (Table 3.10). The BLM lands are typically surfaced with rock, while non-BLM roads may either have hard surface or rock surface. Recently, BLM practice has tended toward construction of natural-surfaced roads specifically for timber sales. After timber harvest is completed, these roads are decommissioned and subsoiled for hydrologic needs.

Roads are a leading source of sediments in forestlands. In the past, they were found to "contribute as much as 90% of all sediments" from these lands (Brooks et al. 1991 as cited in Wolf 1992). However, a recent study by ODF on landslides caused by the 1996 flood found that
The incidence of road-related landslides had decreased. This was taken to indicate that improved road-building practices had resulted in a decrease in road-related landsliding and erosion.

3.3.2.1 High risk areas for road-related slope failures

High risk for road-related slope failures can be expected at sites where roads cross sites otherwise identified with high risk for mass wasting. In the Dairy-McKay watershed, criteria for determining high risk will include the presence of steep slopes. Typically, high risk sites for slope will be expressed as 60% or greater on the topographic map, and moderate risk slopes are expressed as 30 to 60% (Map 3-1). Both the sedimentary and basalt formations are potentially high risk sites for landslides. On Columbia River basalts, the presence of deeply weathered soils is diagnostic of a high risk site.

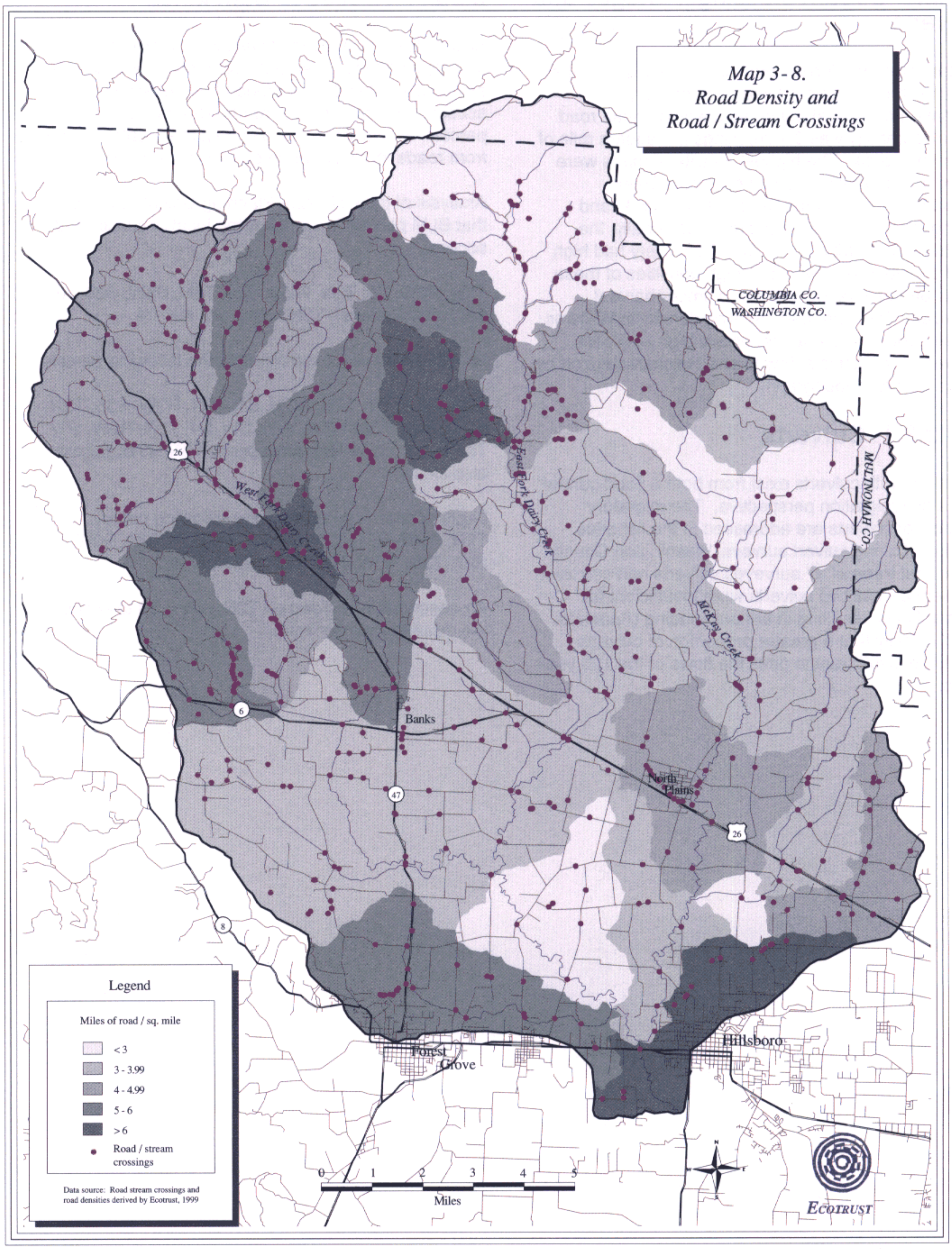
The most extensive areas bearing high-risk characteristics is found in the McKay Creek watershed. Within the McKay - Neil Creek subwatershed, the slopes adjacent to McKay Creek are steep with unstable soils, as are streamside slopes in the East Fork McKay Creek subwatershed. In the latter watershed, Dixie Mountain Road is currently washed out.

3.3.2.2 Road density

Road density provides an indication of the degree of habitat fragmentation caused by roads, as well as potential road-related mass wasting and sedimentation problems. For the watershed as a whole, mean road density was 4.28 miles road per square mile of watershed area. The density of roads varies among the subwatersheds, ranging from 2.12 mi/mi^2 in the McKay-Neil Creek subwatershed to 12.6 mi/mi^2 in Hillsboro North (Map 3-8). The highest density of roads is found in the urbanized southeastern corner of the watershed. Among rural sub-watersheds, the highest road densities are located along West Fork Dairy Creek and around Denny and Murtagh Creeks in the East Fork Dairy Creek drainage. The high densities of these areas probably reflect extensive timber harvest activities. Conversely, the low densities of the middle reaches of McKay Creek are probably the result of steep topography and unstable terrain. BLM parcels, at 3.06 mi/mi^2, had lower road densities than other portions of the watershed.

Table 3-10. Roads within the Dairy Creek watershed.

		Miles	% of total
BLM controlled Roads:			
	on BLM lands	16.81	1.7%
	on other lands	14.29	1.4%
	Total	31.10	3.1%
Non-BLM controlled Roads:			
	on BLM land	14.46	1.4%
	on other lands	953.97	95.4%
	Total	968.43	96.9%
Total Roads		999.53	


Map 3-8.
Road Density and
Road / Stream Crossings
COLUMBIA CO.
WASHINGTON CO.
MULTNOMAH CO.
26
West Fork Dairy Creek
East Fork Dairy Creek
McKay Creek
6
Banks
47
North Plains
26
8
Hillsboro
Forest Grove
Legend
Miles of road / sq. mile
< 3
3 - 3.99
4 - 4.99
5 - 6
> 6
Road / stream crossings
Data source: Road stream crossings and road densities derived by Ecotrust, 1999
0
1
2
3
4
5
Miles
ECOTRUST

3.3.2.3 Stream crossings, bridges and culverts

Stream crossing density provides an indicator of the potential for road-related sediment delivery to streams. For the watershed as a whole, mean road crossing density was 3.1 crossings per square mile of watershed area. The highest density of roads were found in tributaries of West Fork Dairy Creek, particularly the Williams Creek, Sadd Creek, and Garrigus Creek subwatersheds. Additionally, the Murtagh Creek tributary of East Fork Dairy had high road density (Map 3-8). The high densities of these areas probably reflect extensive timber harvest activities. The high road crossing density in Williams Creek could indicate an especially high sediment delivery risk, as this subwatershed is characterized by steep, unstable topography.

3.3.2.3.1 Culverts

Concerns with culverts exist from both a flood control and a fish migration perspective. The migratory impacts of culverts are addressed in the fisheries section. During culvert surveys, Washington County noted that three of 37 surveyed culverts had corrosion problems, while two culverts were insufficient for normal flows, resulting in annual flooding (Appendix 7). It is likely that a greater proportion of culverts would be insufficient to pass the flows of the 100 year flood.

3.3.2.4 Access to BLM lands

Access to BLM lands is necessary to efficient conduction of management operations. However, not all parcels within the watershed have effective road access. In certain cases, roads were not built to parcels. However, in many cases, the problem stems from roads that have been closed by landslides.

Analysis of the Columbia Planning Unit Map indicates that BLM parcels in the following locations lack road access:

T2N, R2W, S9; T2N, R2W, S29; T3N, R3W, S29, NE 1/4 (two locations); T3N, R3W, S9, NE 1/4

Landslides have closed roads to the following parcels:

T2N, R2W, S7; T2N, R3W, S1; T3N, R3W, S35; T3N, R3W, S31; T3N, R3W, S25, SW 1/4; T3N, R2W, S7. The most convenient accesses to T3N R3W, S3 are also closed.

Legal access is needed for the following parcels: T2N, R3W, S21; T2N, R3W, S11 & 12; T2N, R2W, S27; T3N, R3W, S19; T3N, R2W, S21.

An easement is needed on T2N; R2W, S3 to access the existing road network.

Chapter IV: Reference Conditions

4.1 Introduction.

Reconstruction of reference conditions largely depends upon two sources. First, limited records are available giving the impressions of explorers and pioneers as they first saw this region. Although their information was not collected according to the scientific method, it offers valuable firsthand insights into the general distribution of landscape characteristics at the advent of Euro-American settlement. To a large degree, their impressions taken at specific locations can be extrapolated to describe strata within the entire watershed. That is, upland characteristics would be expected to be similar throughout the Tualatin Plain, and likely to be different from riparian characteristics.

The second source is the extrapolation of these impressions based upon geographical, geomorphic, and biological principles. For purposes of this report, the reference conditions are assumed to describe the period immediately prior to European settlement. At that time, geological and climatic influences would be similar to those currently experienced. Given pioneer accounts of the vegetational structure of the watershed, and assumptions of negligible human impact prior to this period we can formulate reasoned deductions related to erosion, hydrology, stream channel, and water quality parameters. Such deductions form a major part in the formulation of the reference conditions described below. They are not to be taken as absolute truth, but rather a reasonable description of assumed watershed condition prior to extensive human impact.

Although these reference conditions may describe conditions prior to human impact, we cannot expect to recreate these conditions. In the next chapter, Synthesis, we will delineate a set of conditions that we consider to be realistic management goals given the current conditions of the watershed.

4.2 Erosion

Prior to human settlement, the vast majority of the Dairy-McKay watershed was heavily forested, with a large proportion of the watershed in old-growth timber. Such conditions would have provided little opportunity for surface erosion. Most surface erosion would occur in episodic pulses for about 20-40 years following stand replacement fire events. In the nearby North Yamhill watershed, such events were estimated as occurring every 200 years (BLM 1997). Thus, it is reasonable to believe that low surface erosion rates characterized the watershed about 80-90% of the time. Additionally, local increases in surface erosion would have been effected at locations where the tree canopy had been disturbed by large storms, wind, or disease.

Mass wasting processes would also have been episodic, being mainly associated with fires and major storm events. The rate of mass wasting (as well as surface erosion) would have been lower than present rates due to the lack of roads. The heavily timbered stands were probably less susceptible to mass-wasting than current clearcuts. However, recent studies by ODF show that mature timber can have landsliding rates similar to those for clearcut stands (Dent et al. 1997).

Streambank erosion would probably have occurred at lower rates than those presently observed. Most evidence from the early 1800s indicate that near-stream areas were heavily vegetated. Although natural stream meandering would have resulted in bank erosion, the increased resistance provided by vegetation, roots, and large wood in streams would have slowed this process.

Where erosion did occur, less sediment would probably have been delivered to streams than is presently the case. Due to high relative humidity and lower fuel temperatures, many riparian zones were more resistant to fire than upland sites (BLM 1997). This effect was strongest in lower watershed elevations. Where riparian vegetation and surface cover remained intact, it would have provided resistance to surface flow and encouraged deposition. Substantial wetland areas and floodplains would also have provided opportunity for sediments to settle outside the active channel.

4.3 Hydrology and water quality

4.3.1 Tualatin Mountains

In the Tualatin Mountains, hydrologic processes would probably have been similar to those occurring now. Forested conditions would have led to high rates of interception. Thick layers of forest duff would readily have allowed infiltration. Evaporation rates were probably quite high, but it is not clear that these rates would have been different than those under present forested conditions.
Peak flows in the mountains were probably lower than current peaks. Due to the absence of roads, fewer opportunities for channeled flow would have been present than under current conditions. Runoff that is now channeled into road ditches and into the stream system would have had greater opportunity to infiltrate. This would have resulted in downstream peak flows lower by an undetermined amount than under present conditions. Additionally, subsurface flows would have been higher than current levels. Stand replacement fires would have altered the surface hydrology. Diminished soil infiltration capacity, along with decreased ground cover would have resulted in increased surface storm runoff. Reductions in evapotranspiration rates could have increased the quantity of water available to streams for up to 40 years (BLM 1997). During this period, increased summer flow could potentially have benefited fish. However, this benefit would have been temporary, as these flows would gradually diminish as the fire-stricken areas revegetated themselves. Where these stands were replaced with phreatophytic hardwoods, evapotranspiration rates may have been above original levels, resulting in decreased streamflow.
Much less of the watershed was probably covered with hardwoods than is presently the case. This probably means that less evapotranspiration took place, resulting in increased water availability for aquatic life.

4.3.2 Tualatin Plain

The hydrology of the valley plain would have been substantially different than that now experienced. Prior to diversions, summer low flow in Dairy Creek would have been considerably higher. The difference was probably substantial, as illustrated by changes in low flow in the Tualatin River. In 1895, the depth of the Tualatin River downstream of Hillsboro always exceeded 3 feet (Cass and Miner 1993). In the years immediately prior to creation of Hagg Lake, the river was known to dry up (water rights seminar, Pacific University, October 3, 1998).

Peak flows would likely have been lower due to retention in floodplains and wetlands. During winter flooding events, water would have been detained for substantial periods of time. In addition to benefits for sediment control and wildlife, these detained waters would have seeped slowly back into the creeks, thus moderating flood peaks and increasing the water available during lower flows. Some of this water would also have become available to replenish subsurface supplies. Additionally, greater in-channel vegetation and large woody debris would have detained flow and dissipated stream energy during high flows.

Although peak flows would have been moderated, flooding would have been a frequent occurrence. Factors contributing to the flooding of Dairy Creek include the low gradient of the stream, and in earlier times would have included the congested nature of the channels.

4.3.2.1 Extent of wetlands in the early Dairy-McKay watershed

Early trapper reports note that most of the Tualatin Valley was wet and swampy (Cass and Miner 1993). Physical factors played the greatest role in creating these wetlands. Flat topography impeded the flow of surface water, while low soil permeability decreased infiltration. Additionally, locally high water tables would rise to the surface in the winter, creating standing pools of surface water (Hart and Newcomb 1965).

Beavers also contributed to construction of ponds and marshy areas in the Tualatin Plain (Cass and Miner 1993). Among other effects, beaver dams "increase hydraulic residence time and flood extensive areas, capture and retain sediment, and facilitate nutrient processing and storage" (Shively 1993).

Analysis of survey maps from 1870 showed that extensive swampy areas occupied the Dairy-McKay watershed. The largest of these areas were in the West Fork Dairy Creek drainage, and included Lousignont swamp, which occupied an estimated 855 acres, and the swamp along Cedar Canyon, which occupied an estimated 560 acres. Three other sites near the West Fork contributed another 265 acres of wetland.

Other tributaries to Dairy Creek also had sizeable wetlands. In the drainage of the East Fork of Dairy Creek, a wetland of about 330 acres extended along the present course of Bledsoe Creek, with another 140-acre wetland along nearby Bausch Creek. East Fork Dairy Creek, itself, had a 150-acre wetland north of Mountaindale. On McKay Creek, the only mapped wetland extended for about 210 acres. It was on the reach between Jackson Creek and Brunswick Canyon.

These wetlands add up to a total of 2,320 acres (3.6 mi^2), about 1.5% of the total watershed area. However, this estimate is probably very conservative as wetlands were inconsistently mapped in the 1870 survey. On a particular quad, adjoining areas would be mapped as wetland, but no such designations were made on the applicable quad. Additionally, known wetlands, such as Jackson Bottom, were not mapped.

4.4 Stream Channel

Stream channel characteristics would have been relatively stable prior to the time of human influence. Large inputs of down wood during large storms were relatively stable over time, and would likely have persisted through the periods between disturbances. Sediment would have been input and transmitted through the system in pulses corresponding to periods of high landslide rates. The routing of water and sediment through the watershed was controlled by the extent and condition of riparian vegetation, especially in the lower watershed where gradients are lower and the floodplain more developed.

Based on historical records, stream channels throughout the Dairy-McKay watershed had abundant vegetation. The trees and their roots tended to restrict channel width (Shively 1993). Additionally they had jams of woody debris, and sediment. The abundance of woody debris likely would have resulted in more diverse instream structure. Pool development, in particular, would have greatly exceeded current levels. It is also likely that these large woody debris elements would have provided better retention of spawning gravels.

Prior to channelization, most stream channels in the Tualatin Plain portion of the watershed would have experienced extensive meandering. The high silt-clay content of channel banks and substrate indicates that then, as now, channels had a low width to depth ratio. Little evidence exists regarding stream dimensions within the watershed in the early days of settlement. However, one survey performed in 1897 gave dimensions at two points on Dairy Creek. At the mouth, creek width was reported as 40 feet. Width was 12 feet at river mile 13. "The banks were from 15 to 25 feet high throughout and the fall about 50 feet in all or 4 feet per mile" (Farnell 1978). Unfortunately, uncertainties about the measurement methodology of the surveyor makes comparison with present stream characteristics difficult.

4.5 Water Quality

Water quality prior to human intervention was partially a function of the condition and extent of riparian vegetation. Water quality characteristics would have varied widely across the landscape and over time as a result of the extent of disturbance of the riparian zone.

Under undisturbed conditions, abundant stream canopy would have provided for stream temperatures cooler than those currently experienced. It is unclear what the temperature regime would have been for wetland areas, nor for water contributed to streams from these wetlands. During periods of major disturbance of riparian vegetation from fire or windthrow, water temperatures were elevated. In the periods between those major disturbances, water quality was good in those areas with adequate riparian vegetation.

Sediment levels were similarly affected by disturbance events. Where the riparian vegetation was intact, it would tend to restrict sediment delivery to streams, both through binding of soil, and detention of sediment-laden runoff. Following disturbance, these factors limiting sediment contributions would be reduced, leading to accelerated sediment contribution to streams.

Phosphorus levels would have been naturally high in the West Fork and East Fork drainages, and in the alluvial sediments of the Tualatin Plain. For the most part, this would have been dissolved phosphorus, as particulate phosphorus inputs would have been restricted by vegetation, other than in burnt and disturbed areas. Additionally, the extensive wetlands prevalent at the time would have helped to remove particulates, including phosphorus.

Contributions of bacteria would have been supplied by wildlife. However, these contributions were probably much lower than those attributable to livestock raising and septic systems.

Levels of nitrate and nitrite, and ammonia nitrogen would have been much lower in the reference period. Limited amounts of nitrogenous compounds would have been available from naturally occurring organic detritus. However, contributions of these substances from fertilizers, livestock, sewage and urban runoff would have been absent.

Dissolved oxygen levels would have been higher. Lower water temperatures would have increased stream capacity for oxygen, while reduced inputs of organic waste and nutrients would have reduced the biochemical demand for oxygen.

4.6 Aquatic Species and Habitat

4.6.1 Fish

Historical fish habitat information is not available at this time. Fish habitat can be interpreted from general vegetation descriptions of the land and estimated human impacts. It can be assumed that prior to extensive timber harvest, road construction and settlement, fish habitat was most likely in better condition. This is probably a result of larger woody material entering the stream channels creating structure and pools desirable for fish production and survival. Fish passage was not impeded by dams or water diversion structures. Water quality was generally better except after major forest stand replacement occurrences such as large fires.

Due to the mature state of most of the riparian timber in the watershed, streams received ample contributions of large woody debris. This would have contributed to higher pool development and greater instream habitat diversity, which would have been beneficial to aquatic life. Additionally, the mature riparian timber provided ample shade for streams. The resulting low water temperatures and high dissolved oxygen levels would have benefited salmonids and many other cool-water aquatic organisms.

Benefits from large woody debris would have extended to streams within the valley plain. Although the extent of spawning substrates would probably have been similar to those currently occurring, the increased incidence of LWD-induced pools, as well as lower temperatures, would have provided more useful salmonid rearing habitat than is now currently available.

Prior to stream clearing and channelization, stream meanders would have provided greater length of total aquatic habitat. Additionally, this habitat would have been more complex. Instream wood would have provided cover elements for fish, as would tree roots in the banks and hanging vegetation.

It is likely that steelhead would have been the only native anadromous salmonid species in the Dairy-McKay watershed during the reference period. The presence of Willamette Falls restricted the distribution of sea-run cutthroat trout. It is unlikely that a substantial population of chinook salmon ever populated the watershed (Ward 1995).

Other streams throughout Western Oregon have documented declining trends for most salmonid species over the last century. This, along with the availability of better habitat, indicates that the Dairy Creeks populations of cutthroat trout and steelhead were larger than those occurring today. However, historical references to fish populations and habitat within the watershed are difficult to find. One anecdotal source notes that trout were abundant in McKay Creek in 1930 (Nelson and Tannock 1998).

4.6.2 Wetland and riparian dependent species

The greater extent of wetland and riparian areas would have provided increased carrying capacity for species dependent on these habitats. This habitat was utilized by greater numbers of waterfowl. In the mid-1800s, for example, anecdotal accounts describe immense flocks of migrating ducks in the Banks area (Fulton 1995). The smaller wetlands created by beavers provided particularly important habitat for pond turtle populations. Trees felled by beavers would have provided habitat for basking, foraging, and refuge (Altman et al. 1997).

These extensive wetland habitats could also have sustained greater numbers of amphibians. Amphibian communities would have consisted of native frog and salamander species. Many of these species, as well as the Western pond turtle, have dwindled since the introduction of the exotic bullfrog.

4.7 Vegetation

4.7.1 General regional characteristics

The watershed area is within the western hemlock zone described by Franklin and Dyrness (1973). Old-growth stands in this zone still retain a major component of the seral species, Douglas-fir. In 1850, nearly 80 percent of the land area in the Oregon Coast Range north of Tillamook was essentially a continuous block of forest over 200 years old (Teensma et al. 1991). These extensive tracts of old-growth forest were broken by patches of 100- to 200-year-old stands and a very small amount of recently burned area. According to Oliver and Larson (1990), the general structural features of these old-growth stands typically include large, live old trees; large, standing dead trees; variation in tree species and sizes; large logs on the forest floor in various stages of decay; and multiple-layered canopies. These stands also have a great deal of horizontal and vertical diversity.

To gain an appreciation of the characteristics of these forests, we can refer to the interim minimum standards for old-growth Douglas-fir described by Franklin et al. (1986). These include:

- Two or more species of live trees with a wide range of sizes and ages.
- Eight or more large (>32 inches diameter at breast height (DBH)) or old (>200 years) Douglas-fir trees per acre; however, most stands have 15 to 45 trees per acre, depending on stand age and history.
- Twelve or more individuals of associated shade-tolerant species per acre, such as western hemlock or western redcedar, that are at least 16 inches DBH.
- More than 15 tons of down logs per acre, including 4 pieces per acre more than 24 inches in diameter and greater than 50 feet long.
- Four or more conifer snags per acre. To qualify for counting, snags must be greater than 20 inches in diameter and more than 15 feet long.

Other features of these old-growth forests include a dense, multiple-layered canopy; decadence in dominant live trees as evidenced by broken or multiple tops and decay; and shade-tolerant climax species, such as western hemlock or western redcedar, in canopy gaps created through the death of the dominant Douglas-fir trees.

Wildfire, wind, and disease appear to be the primary disturbance agents influencing the development of these stands. Wildfire is by far the most significant of these agents. Although fire frequency in the Coast Range has not been determined, it probably occurs at intervals ranging from 150 to 350 years and was associated with east wind events (Teensma et al. 1991). These rather infrequent fires, however, were high-intensity, catastrophic, stand-replacement events. It seems likely that human-caused fires dominated the pattern of fire occurrences in the Coast Range both before and after European settlement. Lightning was probably not a major cause of fires, especially since fire protection and cause determination began in 1908.

Fire results in both the creation and loss of down wood from the system. Large pulses of down wood have been noted following stand-replacement fire events (Spies et al. 1988). Following fire in an old-growth western hemlock/Douglas-fir forest, there was a 10-fold increase in snags. In addition, the total biomass of down wood increased from 244 tons/acre in the old-growth stand to 565 tons/acre in the newly burned stand (Agee and Huff 1987).

Major wind events associated with winter storms also may have influenced the development of these stands. Windthrown trees add down wood to the forest floor, as well as creating various-sized canopy gaps that support species such as western hemlock and western redcedar. In addition, major windthrow events create conditions for population build-up of the Douglas-fir beetle. Subsequent tree killing by these beetles further adds to the snag and down wood component of these forests as well as creating additional canopy gaps.

Laminated root rot, caused by the fungus *Phellinus weirii*, is widespread and probably had an important influence on the structure of many stands in the watershed. *P. weirii* is a native root pathogen that readily attacks and kills Douglas-fir (Thies and Sturrock 1995). Tree killing creates gaps in the canopy where shrubs, hardwoods, or shade- and disease-tolerant conifer species occupy these various-sized openings. Tree killing also creates snags. In addition, infection predisposes trees to windthrow. Live infected trees are susceptible to attack and killing by the Douglas-fir beetle. This disease, therefore, is a major source of down wood and snags.

Prior to European settlement, exotic weed species were not abundant on the landscape. There were, no doubt, a few populations of exotic species introduced through animal migration and Native American travel. Many of the exotic species currently within the watershed were brought into the area as ornamentals, to control erosion processes, or entered as seeds or spores on vehicles or clothing.

4.7.2 Vegetational characteristics of the Tualatin Mountains

Prior to European settlement, vegetation characteristics for the Tualatin Mountains would have been similar to those described in the previous section. The land would have been mostly forested with timber in the mature/old-growth structural stage. Interspersed in this sea of old-growth were stands of younger timber where stand-replacement fires had occurred. Most surveys from the mid-1850s describe the Tualatin Mountains as thickly forested, rough land with little capacity for settlement. However, an area of Dixie Mountain near the present site of Skyline Road was described as open country. This was attributed to burning by Native Americans (Nelson and Tannock 1998).

4.7.3 Vegetational characteristics of the Tualatin Plain

In the mid-1800s, the Tualatin Plain was a forested region interspersed with wetlands and prairies. Letters by early pioneers describe the forests as consisting of fir and oak. Their descriptions of prairie size range from 1 square mile in area, to 2 to 10 miles in linear extent (Buan 1995). These prairies provided valuable grazing and farm land. One such prairie extended south of Banks. Surveyors in 1851 described this area as a level prairie with first rate, clay loam soil (Fulton 1995).

At this same time, the area north of Banks also appeared to be in early successional condition. In the 1851 survey, this area was reported to contain "open fern and hazel, and hills with scattered firs" (Fulton 1995). Fire probably played an important role in creating this open vegetation pattern.

For the most part, the hills at the fringe of the plain were forested. The 1851 survey described one such hilly area in the East Fork Dairy Creek drainage (northeast portion of T2N, R3W) as forested with fir and some cedar, with an understory of maple and fern (Fulton 1995). Soils in these hills were considered to be "second rate".

4.7.4 Wetland vegetation

The characteristics of the Dairy Creek wetlands can be determined from early surveys of nearby wetlands. Just outside of the Dairy Creek drainage, 1852 surveys characterized Tualatin Valley bottomland as thickly forested with fir, ash, maple and vine maple, with many swamps thickly wooded with 10- to 20-foot willow (Shively 1993). Cass and Miner (1993) state that western hemlock, western red cedar, hazel, dogwood, salal, and Oregon grape were also important components of wetland habitats. Based on these assessments, it would be reasonable to assume that the many of the Dairy Creek wetlands were similarly wooded. However, settlers' accounts of lush meadow grasslands, together with the assumption that many of these grasslands were created by flooding, indicates the presence of marshy wetlands as well.

4.7.5 Sensitive plant species

It is difficult to reconstruct the abundance and distribution of sensitive plant species during the reference period. Factors complicating historical information regarding survey and manage species and other sensitive plants are as follows:

- Survey and inventory in the past has predominantly been limited to vascular plants (even vascular plant surveys are very limited);
- Sightings are few and widespread for most plant species, indicating large gaps in range information;

- Only the most rudimentary of ecology data is available for many species; therefore, habitat requirements are essentially unknown for most of these species, historically and presently; and,
- Sighting location information is often general, with little specific information available.

Those species dependent upon old-growth forest habitat, as well as riparian and wetland species, would have had a greater area of available habitat. It is likely, therefore, that these species were more abundant, and more broadly distributed, than is currently the case.

4.7.6 *Terrestrial Species and Habitat*

Prior to European settlement, the Northern Oregon Coast Range which forms the northern and western portions of the Dairy-McKay watershed was made up of larger blocks of later seral stage forests comprised of a wide range of tree sizes, large amounts of down wood, and abundant large snags. This situation undoubtedly provided habitat for those species dependent upon, or which would utilize larger blocks of interior forest old-growth habitat. Species that are presently of concern within the watershed such as the spotted owl, pileated woodpecker, and red tree vole benefited from the historical habitat condition.

The contiguous nature of the landscape pattern facilitated the free movement of these species throughout the watershed and throughout the region. Old-growth habitat conditions extended down into moist riparian areas and shaded the streams which contained numerous pools as a result of many large logs and debris jams. These riparian areas functioned as corridors for wildlife including amphibians, otter, elk, and cougar.

Abundant habitat suitable for spotted owl would have existed prior to European settlement. The owls would have had the extensive old-growth forest that would provide nesting and roosting habitat.

Abundant habitat for marbled murrelet would have existed in the watershed, as the vast majority of stands would have been in the mature to old-growth stages. The old-growth forest characteristics would also have provided abundant snags for bald eagle nesting.

Due to the limited amount and/or distribution of early-successional stands, forage habitat may have limited deer and elk populations within some portions of the watershed. These species would probably have occupied territories near recent burns, and probably would have had a substantial presence near the prairies of the valley plain.

The Columbian white-tailed deer (*Odocoileus virginianus*) occupied prairie habitat throughout the Willamette Valley, including the Dairy-McKay Creek watershed (Verts and Carraway 1998). Shortly after settlement, these deer were extirpated from most of their range in Oregon. Remnant populations are found in Clatsop, Columbia, and Douglas counties. The Columbian white-tailed deer is currently listed as endangered under the federal Endangered Species Act.

4.8 Human

4.8.1 *Historical changes in landscape pattern*

Human occupancy in the Dairy-McKay watershed has been a major source of change. The progression of some of the activities leading to changes in watershed conditions is given below.

4.8.1.1 Human uses prior to European settlement

The Tualatin Indians (also known as the Twality, or Atfalati), occupied a number of small villages in the Tualatin Plain. Six winter villages appear to have been located within the Dairy-McKay watershed. Three of these villages were at or near the present site of Forest Grove, with the other three north of Hillsboro. One of the largest of these villages was at the present site of North Plains. Additionally, a number of artifacts have been found near Mountaindale (Cass and Miner 1993, BLM 1979).

In many parts of Oregon, Indians modified the landscape through burning. Fires were set to maintain land in a herbaceous state, which facilitated hunting and travel, and created browse for deer and elk. The Twality Indians, whose diet mainly consisted of large game, do not appear to have utilized agricultural burning to the same extent as some other tribes. They did, however, harvest vegetables, such camas, tarweed, and berries. Fishing was also part of their subsistence base. The Tualatin valley floor was maintained as marsh grassland, but this may have been the result of natural flooding, rather than field burning (Cass and Miner 1993).

4.8.1.2 European settlement and agricultural conversion

European settlement began in the 1820's with Hudson's Bay Company trappers. At this time, their activities centered around beaver trapping. However, by the 1830's declining beaver numbers led some of these trappers to take up farming (Nelson and Tannock 1998). Although Hudson's Bay Company policy was to leave areas where beaver depletion was occurring, numbers continued to decline. By 1846, concerns were voiced that beaver would be eradicated from the Tualatin Basin (Cass and Miner 1993).

In the 1830's, the Hudson Bay Company raised livestock in the meadows of the Dairy-McKay watershed. Cattle were driven from Scappoose over the Tualatin Mountains to summer pasture in the watershed. A dairy was opened in the watershed, leading to the naming of Dairy Creek. The products of these operations were used to supply nearby Fort Vancouver. The Hudson's Bay Company also ran hogs in the watershed. After the company ceased operations in the area, many of these hogs were left to run wild (Cass and Miner 1993, Fulton 1995, Nelson and Tannock 1998).

Prior to 1840, there were very few American settlers in the Tualatin Valley, and these were primarily fur trappers. All of these settlers were located east of Dairy Creek (Buan 1995). Twenty-five donation land claims were listed prior to 1840. Settlement quickly accelerated between 1840 and 1855. The first large migration to the Tualatin Basin occurred in 1843 (Cass and Miner 1993, Fulton 1995).

During European settlement, the pace of change accelerated. Woodlands and prairie in the Tualatin Valley was rapidly converted to agriculture. Settlement and accompanying agricultural conversion occurred first in the natural meadows. Later settlers cleared forested portions of the valley. Agricultural conversion of the Tualatin Valley continued until 1950, when it stabilized (Shively 1993).

Most agriculture in the mid-1850s emphasized production of livestock and wheat. Settlers also planted orchards. By 1890, apples, cherries, pears, plums. onions and potatoes were commonly available.

The settlers also accelerated the pace of vegetation change through fire. In Western Oregon, it was estimated that "approximately seven times as much land was burned from 1845 to 1855 as in any of the three previous decades" (Morris 1934 as cited in BLM and USDA Forest Service 1997).

4.8.1.3 Timber operations

Beginning in the late 1800s, the watershed was extensively logged. Timber extraction started first in the Tualatin Plain. Initially, these operations were designed to clear homesteads. Then timber operations expanded to sites near settled areas. Hillsboro and Cornelius became important milling centers. Expansion continued along waterways, and sawmills were built along all major streams in the watershed (Farnell 1978). Small communities, such as Mountaindale and Snooseville, formed around these sawmills.

Early transport of logs was most efficiently performed by water. Between 1850 and 1910 numerous log drives occurred along streams within the Dairy-McKay watershed. Log driving was primarily concentrated on the Mainstem and West Fork of Dairy Creek (Farnell 1978). Although splash damming was practiced in other parts of the Tualatin Basin, it was uncommon in the Tualatin watershed. West Fork Dairy Creek had one splash dam between 1880 and 1910. No other splash dams are recorded for the watershed (Shively 1993, BLM 1979).

In the early 1900s, railroads opened up much of the mountainous portion of the watershed to logging. Temporary railroad grades were built into logging sites in the mountains, and logs were transported to mill sites in the valley. North Plains and Banks became important sites for distribution of milled timber.
For many years, timber production continued at high rates. However, during the mid-1950's production dropped sharply as the supply of available timber became depleted. At this time Hart and Newcomb (1965) remarked that the only timber left was in the steeper, more inaccessible portions of the watershed.

4.8.1.4 Wetland conversion

In order to reduce flooding, debris jams, beaver dams, and obstructions caused by tree roots were cleared from streams. This practice was common around 1910. Among the streams where the flooding condition, and by assumption, the cleanout occurred was "the Tualatin and its branches". Brush clearing also occurred in the 1930's as part of flood control projects administered by the Works Progress Administration (WPA). These activities were focused on lowland streams, including many in agricultural areas (Shively 1993). It is reasonable to believe that some of these projects may have taken place in the Dairy-McKay watershed.

In the late 19th and early 20th centuries, the wetlands in many parts of the Tualatin Valley were drained for agriculture. Drainage districts were formed to reclaim wetlands and clear out streams. In 1887, one such district is recorded as clearing Dairy Creek and its west fork as far as the Lousignont swamp, near Kansas City in the drainage of West Fork Dairy Creek. By 1914, an irrigation district had been formed to drain the swamp itself. In 1920, two channels were opened up, which reclaimed a sizeable amount of farmland. Apparently, large portions of the swamp remained until 1940 (Shively 1993, Cass and Miner 1993). Current topographic maps only show a small swampy area southeast of Kansas City. Another drainage project occurred in the Jackson Bottom area (Shively 1993).

These drainage projects resulted in an extensive loss of wetland habitat. One study estimated that 61% of Tualatin Valley wetlands had been lost due to conversion and drainage (Gabriel 1993, cited in Shively 1993).

Small wetland areas persist in the Dairy-McKay watershed, particularly in the West Fork Drainage (Map 3-2). Additionally, a large wetland area remains in Jackson Bottom, which lies partially in the watershed. This wetland supplies several benefits, including the removal of nutrients from secondarily treated sewage effluent released by the Hillsboro West Treatment plant. An assessment of functions and values provided by this wetland was conducted on behalf of the Unified Sewerage Agency (USA). The wetland was found to have high social significance due to sediment/toxicant retention and nutrient removal/transformation. Additionally, this wetland was found to perform functions related to groundwater recharge and discharge, flood flow alteration, and sediment stabilization (Van Staveren et al. 1991, as cited in Shively 1993).

Chapter 5: Synthesis

5.1 AQUATIC

5.1.1 Erosion issues

5.1.1.1 Changes in erosion processes following settlement

The current condition for erosion processes varies from the reference condition in the rate and timing of erosion. Under reference conditions there were large increases in erosion rates associated with major disturbances such as fires and large storms, after which erosion rates dropped to relatively low levels. Removal of vegetation and compaction and displacement of soil from logging and road construction have created an increase in erosion rates that has been going on for a much longer time than under natural conditions. In addition, the type of material delivered to stream channels and riparian areas from landslides has changed. Landslides were a major source of large woody debris in historical times, when there were large areas of older timber in the watershed. The large wood supplied through these processes was relatively stable in the stream system, providing structure and altering flow patterns to contribute to pool formation. With the younger timber that dominates the watershed today, there is little or no large wood input to the channels from landslides, and this is reflected in the lack of large wood and structure in the channel. The smaller wood provided by young timber is readily transported during high stream flows, and provides little lasting benefit to habitat structure.

5.1.1.2 Management impacts on erosion, Tualatin Mountains

These changes in watershed process have largely been the result of changes in management practices since Euro-American settlement. In the Tualatin Mountains, these changes were largely the result of timber operations. The greatest impacts in this region would have occurred between 1910, when railroads opened the mountains up to timber operations, and 1954, when most forests in this region were effectively depleted. During this period, timber operations proceeded with little regulation and little regard for watershed condition. Skidding practices common during this period would have resulted in extensive disturbance of the surface soil and litter layer, resulting in greatly accelerated surface erosion. Additionally, unsound logging practices on steep slopes would have resulted in increased incidence of mass wasting. No riparian buffers were utilized during this period, resulting in increased bank erosion and sediment delivery to the channel. Doubtless, this would have resulted in increased instream sedimentation, leading to reduction of pool volume and siltation of spawning gravels.

Since passage of the Oregon Forest Practices Act in 1973, forest practices have substantially improved. Subsequent changes in Forest Practice Rules have mandated practices designed to reduce disturbance of soils and riparian vegetation during forestry operations. For example, current forest practice rules require high-lead yarding on steep slopes and provide for riparian buffer zones where special timber harvest rules apply. Although these changes have resulted in diminished surface erosion, mass wasting, and sediment delivery from forest operations, effects of past practices still persist.

Despite improved forest management practices, steep and geologically unstable lands in the watershed remain susceptible to debris slides and slumping. For example, two large slumps developed in 1995 in the Williams Creek subbasin in association with heavy rainfall events. These slumps may have been associated, either with the old railroad grade near their head, or with timber operations above the railroad grade. The high incidence of such slumping indicates that management activities in steep lands should be scrutinized, and possibly avoided. Such areas may exist anywhere in the mountains, but are particularly abundant along McKay Creek and its tributaries between Jackson and Pottratz creeks, as well as Williams Creek (Map 3-1).

The greatest current management-related erosional impacts in the Tualatin Mountains are caused by roads. Most of the road mileage in the basin consists of roads surfaced with rock. These roads are subject to surface erosion of cutslopes, treads, and fillslopes. In unstable areas, roads exacerbate the risk of slope failure, as road fill increases the burden upon underlying slopes, while road cuts reduce the strength of the slope above the road. Additionally, drainage ditches create channeled flow, resulting in increased erosive power of runoff, and increased sediment delivery to streams. Stream crossings also provide a ready source of road-related sediment contributions to streams.

Based upon the above considerations, it appears that erosion control efforts in the mountainous portions of the Dairy-McKay watershed would best be concentrated in areas of steep slope and subbasins with high densities of roads and stream crossings. Subbasins of greatest concern for slope stability include McKay Creek and its tributaries between Jackson and Pottratz creeks, and Williams Creek. Road related considerations seem greatest along the West Fork of Dairy Creek, where roads and their crossings occur at high density throughout the region north of Banks, as well as the Sadd Creek subbasin. The Murtagh Creek tributary to the East Fork of Dairy Creek also appears to have high potential for road-related erosion and sediment delivery (Map 3-8).

5.1.1.3 Management impacts on erosion, Tualatin Plain

European settlement caused extensive changes to erosional processes within the Dairy-McKay Creek watershed. With settlement came a number of land use activities that exposed land surfaces to rainfall impacts, increased surface runoff, and reduced the strength of streambanks. Most of these new land use practices resulted in accelerated erosion.

An early contributor to erosion in the Tualatin Plain was the extensive conversion of forestland to agricultural purposes during the latter half of the 19th century. Such conversion exposed extensive acreage to raindrop impacts and increased surface erosion. As the conversion has largely been permanent, increased erosion remains to the present.

Between 1850 and 1950, extensive modifications were made to stream channels. Channels were straightened and cleared of brush, and access to floodplains was cut off. The increased peak stream velocity and water depth resulting from these changes have increased the erosive capability of the streams, likely resulting in increased channel entrenchment. Additionally, vegetation clearing has reduced bank resistance to erosion. Some of these changes can be considered irreversible, as the streams in many reaches are likely to remain in the channelized state with continued floodplain disconnection. Due to lack of study, it is unclear whether channel entrenchment is currently occurring.

Prior to 1996, there was little regulation of farming activities in riparian zones. Riparian vegetation was often removed to the edge of the stream, resulting in increased delivery of surface sediments to streams, decreased bank stability and increased bank erosion. Recent changes in the administrative rules administered by the Oregon Department of Agriculture mandate increased ground cover in winter along streams in agricultural lands.

Erosion due to agricultural sources has been reduced by implementation of agricultural Best Management Practices (BMPs). These practices are usually implemented as part of conservation plans administered by the Washington County Soil and Water Conservation District (SWCD). Certain BMPs, including planting of winter cover crops, mulch tillage, and filter strips, are designed to reduce erosion and sediment delivery to streams. Implementation of these practices has been accompanied by improvements in water quality, indicating that these practices are effective. However, the degree of effectiveness of individual practices is unclear, as no systematic methodology has been implemented to monitor effectiveness of the BMPs. Such a methodology, along with systematic data collection, would be valuable for improving the effectiveness of management systems. Despite the lack of this methodology, it seems apparent that further reductions in erosion and sediment delivery would be achieved by bringing a greater percentage of the agricultural community under Voluntary Farm Water Quality Management Plans.

Changes in hydrology caused by urban influences result in increased peak flows, potentially accelerating erosion at downstream sites. Additionally, urban runoff leads to increased inputs of hydrocarbons and other pollutants to streams. Such effects will generally be concentrated in lower Dairy Creek, lower McKay Creek, and Council Creek.

Effective erosion control in the valley portion of the watershed will largely concentrate on reduction of source sediments from agricultural operations, and from riparian restoration. The former objective is most efficiently achieved through voluntary efforts spearheaded by the NRCS/SWCD. These agencies have a long history of working together with farmers to reduce soil loss. Additionally, these agencies are able to offer economic incentives and cost-sharing programs to implement BMPs. Although enhanced riparian buffers would be beneficial throughout the watershed, the greatest return on effort would probably occur where the riparian buffers are most severely compromised. Such areas include Council Creek, West Fork Dairy Creek between Williams Creek and the confluence with Dairy Creek, East Fork Dairy Creek between Murtagh Creek and the confluence with Dairy Creek, McKay Creek between East Fork McKay Creek and North Plains, and Jackson Creek near its confluence with McKay Creek (Appendix 6).

Certain agriculturally related conditions that lead to accelerated erosion and sediment delivery to streams are prohibited under the Tualatin River Subbasin Agricultural Water Quality Management Area Plan (Appendix 3). Such "Prohibited Conditions" are discussed in the Water Quality Section (Section 5.1.4.6).

5.1.2 Hydrology and water quantity issues

5.1.2.1 Management effects on hydrology

Stream hydrology has been altered from reference conditions. In general, these changes have tended to increase winter peak flows, decrease summer low flows, and increase surface runoff.

Current changes in the hydrologic regime are likely to be minor in the Tualatin Mountains. At higher elevations, occasional rain on snow (ROS) events in clearcut areas may lead to augmented peak flows. Where road density is high, extension of channel networks and compaction of road surfaces may lead to accelerated surface runoff and increased peak flow. Other hydrologic changes related to current timber harvest practices are usually minor and temporary (Washington State Forest Practices Board 1997). Residual effects of past timber harvest practices on channel morphology may continue to affect hydrology.

The greatest impacts on hydrology have been experienced in valley portions of the watershed. Under reference conditions, the stream channel was hydrologically connected with extensive floodplains and wetlands. These floodplains served to moderate peak flows and flow velocity. Floodwaters were detained. Some of the stored water infiltrated to recharge groundwater supplies, while much of the rest was subsequently released to the stream to augment lower flows. Following Euro-American settlement, stream channelization cut off many portions of the stream channel from the floodplain, thus removing the ability of the floodplain to store and moderate flows. This resulted in higher peak flows, a reduction in low flows, and increased flow velocity. Additionally, channel straightening and brush removal associated with channelization also contributed to increased flow velocity. Channel straightening increased stream gradient, while brush removal removed resistance to flow. The amount of recharge to groundwater was also reduced, resulting in a lower water table, and diminished low flows. These changes are relatively permanent, as these channels are maintained with an artificially straightened configuration and with impaired hydrologic connection to their floodplains. Sites where these hydrologic functions were lost or impaired include traditional wetlands of the West Fork Dairy Creek drainage area such as Lousignont Creek and Cedar Canyon. Portions of the East Fork Dairy Creek near Mountaindale, as well as nearby Bausch and Bledsoe

Creeks, provide other examples. Additionally, limited channel straightening and clearing took place in lower reaches of Dairy and McKay creeks for navigation and flood control purposes. Hydrologic effects from these projects would extend for a considerable distance downstream of these sites.

To a certain degree, storage ponds at traditional wetland sites provide a detention function. However, this stored water does not serve to recharge groundwater storage or augment instream flow, but instead is diverted for agricultural uses. A portion of this water could be expected to return to the aquatic system as return flow. However, such return flow is often degraded, with increased temperature, decreased dissolved oxygen, and often enriched with nutrients and chemicals.

Extensive areas of the urbanized lower portions of the watershed have been covered by impervious surfaces. These surfaces have changed the local hydrology by increasing surface runoff to streams and decreasing groundwater recharge.

Prospects for restoration of the hydrologic functions attributable to floodplains and wetlands appear to be limited. Economic activity in the watershed has adapted to the current channel configuration and disconnection from wetlands. Efforts to restore floodplains and wetlands to their original extent are likely to be expensive. Instead, the most effective policy given current constraints is to protect existing floodplain and wetland resources, prioritize high-potential areas for wetland restoration and/or enhancement, and prevent encroachment of new activities that are incompatible with floodplain and wetland function.

Other major changes to stream hydrology have been effected by instream diversions. The vast majority of these diversions have been for agricultural purposes. Such diversions generally take place in the summer low-flow season, further diminishing these flows below natural conditions. Such effects are felt throughout agricultural portions of the watershed, although demand is greatest in East Fork Dairy Creek below Meacham Corner, and in West Fork Dairy Creek below Manning.

5.1.2.2 Water rights allocations

Water rights appear to be overallocated many parts of the year. Due to lack of gaging, it is difficult to say where the greatest potential deficits occur. As most of the valley streams provide little water contribution in summer, it is reasonable to believe that the greatest cumulative effects of overallocation would occur on lower Dairy Creek. The effects of this overallocation is difficult to predict. Due to climatic factors and use of supplemental water sources, actual demand on surface water from Dairy Creek and its tributaries will vary from year to year.

During formulation of its action plan, the Tualatin River Watershed Council considered the purchase of additional water rights to supplement current instream water rights. The present watershed analysis report did not identify specific reaches where aquatic life would benefit from these water rights. Further field study is necessary to establish a need for enhanced instream water rights and to determine the best location to acquire these rights. Recommendations related to acquisition of these rights are given in Chapter 6.

5.1.3 Stream channel issues

5.1.3.1 Management effects upon stream morphology

Current stream channel conditions have changed from reference conditions. In some stream reaches in the Tualatin Mountains, increased sedimentation and reduced riparian vegetation from past forest practices probably made channels wider and shallower. Along most of the valley reaches, streams have been channelized and confined rather than allowing natural meandering.

The most extensive change in channel process throughout the watershed has been the loss of large woody debris elements from the stream system. Under reference conditions, mature forests along the streams supplied large woody debris to the channel, creating hydraulic characteristics suitable for pool formation and increased hydraulic diversity. Following settlement, timber harvest removed large wood from the riparian zone. Additionally, forest practices prior to the 1980's emphasized clearing of wood from channels. These policies and practices have combined to generate a system severely deficient in large wood and lacking the roughness elements necessary to generate adequate numbers of pools. These circumstances have been major contributing factors to the lack of channel structure that currently characterizes the Dairy-McKay watershed.

Changes in forest practices have improved long-term prospects for restoration of large woody debris recruitment potential in the mountainous portions of the watershed. Forests in Riparian Reserves and (possibly) other riparian buffer zones will gradually attain size characteristics suitable to produce large woody debris. Over the short term, however, prospects for recruitment potential are bleak. Most forest stands do not currently have large trees suitable for production of large woody debris. Additionally, deciduous stands have replaced conifers in many riparian areas. This has diminished the potential effectiveness of large wood contributed to streams. Conifers provide durable wood that is likely to provide beneficial effects over long periods of time. Although deciduous stands will eventually contribute large wood to the stream, the wood decays rapidly, and its effect on instream structure will typically last less than five years.

Future prospects for large woody debris recruitment in the Tualatin Plain are not favorable. Although riparian conifers exist on the lower reaches of McKay and Dairy creeks, most streams in the valley have a canopy of young hardwoods. As there is little available nearby seed stock for natural recruitment of conifers, it is unlikely that the characteristics of these riparian zones will change. Thus, it is unlikely that any substantial natural recruitment of large woody debris will occur in the forseeable future. It may be necessary to supplement long-term development of natural recruitment with interim measures such as artificial placement of large wood. Planting of conifers in riparian areas will also contribute to long-term prospects for contributions of large woody debris.

Channel morphology in the valley plain has been heavily impacted by channelization efforts. Primary effects of channelization have been stream straightening, local increase in gradient, and removal of roughness elements from the channel. These, in turn, lead to secondary effects, such as channel incision and disconnection from floodplain. Current land uses and economic considerations limit prospects for restoration of reference stream functionality in channelized reaches. The most effective channel restoration strategies in the valley plain will focus on preservation of existing channel characteristics at relatively high quality sites.

5.1.4 Water quality issues

5.1.4.1 Management effects on water quality

Management activities have had substantial impacts on water quality. Under reference conditions, riparian forests provided shade to streams. Shading regulated water temperatures, resulting in cooler summer water temperatures and increased stream capacity for dissolved oxygen. Additionally, riparian forests provided stability to streambanks, minimizing erosion and accompanying contributions of fine sediments. Subsequent to settlement, many of these riparian forests were removed. As practices prior to 1980 made no allowance for riparian buffer strips, this removal increased stream exposure to sunlight, leading to higher temperatures and reductions in dissolved oxygen levels. Additionally, forest removal led to increased streambank erosion and reduced filtration of sediments from upland runoff. This resulted in increased turbidity and suspended solids.

Agriculture contributed to many of the changes in water quality in the Tualatin Plain. Conversion of lands from forest to agriculture resulted in increased exposure of soils to energy from precipitation. Cultivated soils were more susceptible to erosion, leading to greater sediment loads in surface runoff. Together with compromised riparian buffers, these factors contributed to higher delivery of sediments, adsorbed nutrients, organic matter, bacteria and pesticides to streams. Fertilization also led to contributions of nutrients to streams, while livestock access to streams increased inputs of bacteria and ammonia nitrogen. Surface and subsurface drains increased peak runoff. Continual improvements in management practices have reduced the impacts of these activities upon water quality.

Other land-use conversion activities affected water quality. Filling of wetlands reduced their ability to filter out pollutants, sediments and nutrients prior to stream entry. This resulted in increased inputs to the active channel. Stream channelization destabilized banks and increased stream velocity, resulting in increased erosion rates and concentrations of suspended sediments.

With increased settlement came an increased need for waste disposal. Many of these waste disposal systems did not possess adequate safeguards against contributions of pollutants to surface water. Septic tanks associated with rural residential development have contributed bacteria and ammonia nitrogen to stream systems.

Urbanization has also contributed to water quality problems. Surface runoff from impervious surfaces often carries large inputs of organic pollutants to aquatic systems. Most of these effects have been centered in the lower portions of Dairy and McKay creeks. However, the prevalence of roads has enabled the distribution of automobile-related pollutants throughout the basin.

Roads are notable contributors of sediment to surface water supplies. Drainage ditches associated with roads produce channeled flow, leading to increased erosion. Where these ditches lead to streams, or where roads are built in riparian zones or cross streams, an effective mechanism is created for accelerated sediment delivery and pollutant loading. This leads to higher levels of instream sediments, total suspended solids, and adsorbed particulates. Generally, water quality within the watershed has been improving in recent years. This improvement seems to be correlated with changes in timber, agricultural, and wastewater management practices. This suggests that expanded implementation of Best Management Practices in forestry and agriculture would lead to a continued improvement in water quality.

5.1.4.2 Factors leading to high aquatic phosphorus levels.

The case of phosphorus is more complex than for other water quality parameters. Most phosphorus occurring in streams in the Dairy-McKay watershed comes from natural sources. Groundwater flowing through regions underlain by sedimentary rock or valley alluvium is naturally high in phosphorus (Wolf 1992, TAC 1997). The Tualatin Basin Technical Advisory Committee Nonpoint Source Subcommittee found that background (natural) stream phosphorus levels in the Tualatin Plain typically ranged from approximately 0.10 to 0.15 mg/L. As these are the levels achieved in the lower portions of the Dairy Creek system (summer median = 0.11 mg/L), it appears that improvements in management practices are unlikely to effect major decreases in dissolved phosphorus levels throughout the watershed during summer low flows.

However, some ODA data indicates that summer phosphorus levels have decreased after implementation of agricultural BMP's in the Christensen Creek watershed. These BMP's involved point source reduction from a container nursery and a confined animal feeding operation. It is likely that point source loads of phosphorus also exist in the Dairy-McKay watershed, for example on Waibel Creek, where phosphorus levels are considerably above baseline levels.

A considerable amount of uncertainty surrounds the magnitude of phosphorus loads attributable to various causes. As previously explained, the amount of winter phosphorus load that affects summer phosphorus concentrations is unknown. Manure from animals grazing in wetlands and riparian areas also provides an unknown phosphorus load to aquatic systems. The effect of the infrequent summer runoff events is also unknown. Additionally, it is unknown to what extent inadequate septic systems add a phosphorus load to streams. This load would logically play a role in both summer and winter. Finally, there is a potential for future saturation of phosphorus sorption capacity on soils receiving large amounts of phosphorus fertilizer and/or manure. This could lead to leaching of phosphorus to tile drains, which flow to streams well into summer months.

Thus, although substantial reductions in phosphorus concentrations appear unlikely, it is still important for farmers and rural landowners to implement BMP's for phosphorus.

5.1.4.3 Temperature

Stream temperatures are above desirable levels throughout the valley portion of the watershed. Most of the streams with high water temperatures are included in current 303(d) listings. Past measures do no appear to be adequately addressing temperature issues, as temperature trends appear to be stable or rising. This suggests that thermal moderation should be a high priority for water quality improvement projects. Canopy restoration and streambank protection (to prevent widening) are potential strategies to promote temperature moderation. Potential reaches for such restoration include the upper portions of the alluvial plain, where potential summer rearing by cold water salmonids would be most likely, and the West Fork of Dairy Creek, where the least amount of riparian cover is found.

5.1.4.4 Streams on the Oregon 303(d) water quality limited list

Management-related factors have largely been responsible for problems leading to stream placement on the 303-d water quality limited list. Although more intensive study would be necessary to determine causality, it appears that the following factors are probable causes for diminishment of water quality.

- Council Creek. Low dissolved oxygen levels are probably due to high nutrient levels and stagnant water. Stagnant, eutrophic ponds lie along much of the course. Other possible causes are high water temperatures, agricultural runoff (USA 1994), and near-stream storage of refuse (USA 1994). Potential corrective strategies include improved waste management, canopy restoration, minimization of runoff to streams, and removal of algae prior to decomposition.

- Dairy Creek. High *E. coli* levels are probably due to livestock operations and/or faulty septic systems. Potential corrective strategies include improved management of animal waste, restriction of livestock access to streams, and improvement of septic systems.
- East Fork Dairy Creek. Low summer pH levels are probably due to decomposition of organic material. Although the sources of this material have not been quantified, they include waste inputs from agricultural sources, septic systems, and decomposition of algae. Lower winter pH values were judged to be associated with natural rainfall, resulting in a non-listing. High water temperature is probably due to diminished canopy levels in alluvial portions of the watershed. Potential corrective strategies include canopy restoration, restriction of livestock access to streams, improvement of septic systems, and minimization of nutrient inputs to streams.
- West Fork Dairy Creek. High bacteria levels are probably due to livestock, with a possible role of septic tanks. High temperature is probably caused by poor canopy cover, related stream widening, and stagnant flow. Low dissolved oxygen levels are probably caused by a combination of high temperature and high oxygen demand created by inputs of waste and fertilizers. Potential corrective strategies include restoration of stream canopy, minimization of riparian zone sedimentation, minimization of inputs of eroded material and fertilizers from upland sources, restriction of livestock access to streams, and improvement of septic systems.
- McKay Creek (downstream of the East Fork of McKay Creek). High year-round bacteria levels are likely caused by livestock operations with possible septic tank influences. However, recent SWCD surveys found few obvious sources of waste to the creek. Temperature problems are probably due to canopy loss. Potential corrective actions include distancing livestock from streams, improvement of septic systems, and restoring riparian vegetation.

5.1.4.5 Effects of water quality on recreation

Current water quality limits the ability of streams in the watershed to support recreation. For example, instream contact recreation is reduced on Dairy Creek and its West Fork, as well as McKay Creek due to high *E. coli* counts. Further, eutrophic conditions on portions of these streams probably diminishes the desirability of contact recreation.

Diminished water quality also has indirect impacts on recreation. Poor water quality is one of the factors contributing to diminished salmonid populations, which in turn leads to diminished cold-water fishing opportunities. Conversely, increased water temperatures may have improved prospects for warm-water fishing opportunities.

Strategies to restore recreation opportunities are similar to those given to obtain other desirable water quality objectives. Implemention of water quality strategies to reduce nutrient loads, sediments, and bacterial inputs will create conditions more desirable for stream-related recreational activities.

5.1.4.6 Prohibited conditions

Agricultural portions of McKay Creek, Dairy Creek, and selected tributaries were surveyed by SWCD personnel to determine the prevalence and location of conditions prohibited under the Tualatin River Subbasin Agricultural Water Quality Management Area Plan (Appendix 3). During this initial survey, problems related to waste management (i.e. placement of wastes or animals where waste has the potential to enter streams), nearstream soil erosion, and riparian condition (i.e., farming operations inside of the 25 foot buffer, as well as active bank erosion) were surveyed. These conditions were not found to be widespread in surveyed portions of McKay Creek and Jackson Creek. Those problems that do exist were generally clustered along a portion of McKay Creek north of its confluence with Jackson Creek, and lower portions of Jackson Creek. Similar studies are now being conducted on East Fork Dairy Creek and West Fork Dairy Creek. Preliminary indications are that a greater incidence of prohibited conditions will be found along this reach than was found along McKay Creek. However, voluntary farm conservation plans are being developed for many of these locations to address issues related to prohibited conditions.

5.1.4.7 Superfund sites

Hazardous wastes in the watershed do not appear to be a major threat to water quality. All former CERCLA sites in the North Plains area were removed from the Superfund list by the Environmental Protection Agency based on a determination that all necessary remedial actions have been taken at these sites.

5.1.5 Aquatic species and habitat issues

5.1.5.1 Fisheries

Winter steelhead trout and cutthroat trout make up the major focus for habitat and water quality issues in the Dairy-McKay watershed. In addition to their intrinsic value, these species are sensitive to changes in water quality, thus functioning as indicator species of the condition of the stream ecosystem. Cutthroat trout are well distributed throughout the watershed and do not appear to be overly threatened. However, pre-emptive action should be taken to maintain good habitat for cutthroat trout. Declining steelhead trout trends in the upper Willamette ESU, of which Dairy Creek is a part, indicate that steelhead trout within the Dairy-McKay Creek watershed are at risk. *Additionally*, the reduced amount and quality of available habitat suggest a steelhead trout population reduced from original numbers. Trends in coho salmon populations since the end of planting efforts are unknown. For all of these salmonid species, habitat quality and quantity are likely to be limiting factors. The best spawning and rearing habitat for these species is found in the Tualatin Mountains and adjacent portions of the Tualatin Plain and is quite limited in extent, particularly for the anadromous species. Due to management practices of the past, the quality of much of this habitat is diminished from reference conditions. Increased sedimentation and decreased large woody debris inputs have created channels with reduced habitat diversity, including reduced pool frequency and diminished instream cover.

Riparian zone conditions also influence prospects for salmonid habitat in the Tualatin Mountains. Although riparian forests in this region have largely recovered their shading function, they are unlikely to provide appreciable amounts of large woody debris during the near future. This indicates that habitat conditions similar to those existing during the reference period will not be produced naturally during the next 50 years. If riparian forests are allowed to develop mature timber stands, they will eventually regain their ability to provide large woody debris to the stream system.

Mainstem sites in the Tualatin Plain are mainly used for migratory corridors with some limited winter rearing (ODFW 1997 data as displayed in TRWC 1998). Substrates in these streams naturally lack spawning gravels. The greater prevalence of large woody debris in the valley during the reference period indicates that there may have been greater numbers of pools and better stream shading than is currently the case. Under such circumstances, more extensive rearing may have taken place in these streams than is currently observed. However, flow in this region would have been naturally slow, making these streams subject to heating and low dissolved oxygen levels, even under reference conditions.

Lamprey species are susceptible to many of the same habitat concerns as salmonids. Increases in water temperature have provided conditions detrimental to lamprey populations. Additionally, Pacific lamprey in their larval stages make extensive use of fine substrate portions of the watershed. Thus, high water temperatures in stream reaches in the Tualatin Plain are likely to have substantial detrimental impacts to lamprey populations.

Migration by anadromous fish has probably been impeded relative to reference conditions. The greatest obstacles may be caused by roads and culverts. Results of the Washington County culvert survey indicated that a high percentage of these structures did not provide adequate passage to salmonids. The degree of impedance due to these culverts is unknown. Additionally, migration may be inhibited by low water due to diversions. As upstream migration occurs prior to the irrigation system, and enhanced instream water rights are in effect during migratory periods, migratory delay due to diversion may be minor. However, unscreened diversions provide a hazard to fish migrating and rearing in the valley channels

Current aquatic conditions in alluvial portions of the watershed tend to favor non-native aquatic species that prefer warm water, and mesotrophic to eutrophic conditions. These conditions may also result in decreased biotic diversity.

5.1.5.2 Wetlands: Management Impacts.

As under reference conditions, most marshes and wetlands are located in the West Fork Dairy Creek drainage. However, drainage projects in the late 1800s and the early 1900s have severely diminished the extent of wetlands from pre-settlement levels. In the same wetlands expressed by the 1870 maps as 2,320 acres, about 60 acres show up on current topographic maps (50 acres on West Fork Dairy Creek, and 10 acres East Fork). As with the historical wetlands, this number is low, as not all wetlands are mapped. Another estimate can be obtained by analysis of the National Wetlands Inventory, which shows about 845 acres of wetland in these same areas. Although differences in methodology preclude the drawing of quantitative conclusions from these numbers, it is qualitatively apparent that the watershed has undergone drastic reductions in wetlands area. Some of these wetlands have been replaced by storage reservoirs with little riparian buffer and few of the habitat values of the original wetlands.

Other activities also reduced the amount of wetland habitat in the watershed. Trapping of beavers severely curtailed the number of small wetlands. These wetlands would likely have been too small to be recorded on survey maps, but would have provided habitat for waterfowl, and aquatic and amphibian species. A few beaver ponds still remain in the watershed, including a significant wetland up Pottratz Creek. Additionally, other isolated ponds exist in mountainous portions of the watershed. These may or may not be related to beaver activity. The habitat functionality of many of the remaining wetlands has been degraded. This degradation is evidenced by the encroachment of non-native noxious species upon the wetland habitats. Reed canarygrass (*Phalaris arundinacea*) is nearly ubiquitous in wetlands. Purple loosestrife (*Lythrum salicaria*), an ODA schedule B noxious weed, is also a common invader of wetland habitats. Programs to restore native plant species would help to improve the ability of wetlands to provide habitat for native animal species.

Livestock grazing in wetlands can destroy native vegetation and add bacterial and phosphorus loads. Most wetlands in the Dairy-McKay watershed contribute water to a stream, providing a conduit of pollutants to surface water.

5.1.5.3 Riparian habitat: Management impacts

Non-wetland riparian habitat is also diminished in extent and quality from reference conditions. During reference conditions, most valley streams had wide riparian forests. Following settlement, timber and agricultural activities often removed these forests up to the stream channel, leaving no buffer. Riparian habitat would have been completely lost during such periods. Current Oregon forest practice rules provide for a riparian buffer strip along streams. Although such a buffer is of value, it has resulted in a tenuous, thin strip of riparian habitat surrounded by habitat adverse to many riparian species. Thus, the current scenario represents a massive loss of riparian habitat relative to reference conditions.

There are no current regulations requiring trees along streams in the agricultural zone, except insofar as logging in the agricultural zone is also under the auspices of the Oregon Forest Practices Act. Clearing of riparian vegetation for farming, however, is not regulated unless logs are sold commercially.

5.1.5.4 Impacts of wetland and riparian changes upon species

Loss of habitat has undoubtedly reduced the abundance of wetland and riparian dependent species in the Dairy-McKay watershed. However, few to no population surveys have been performed to verify this conclusion.

Although population status of many amphibian and aquatic species is unknown, it is assumed that they have declined with declining habitat. It is hoped that stabilization of habitat amounts will result in a stabilization of populations.

Red legged frogs (*Rana aurora*) appear to be relatively abundant in the watershed. Numerous sightings have been recorded in the East Fork Dairy Creek drainage. During field surveys performed in conjunction with this report, many red-legged frogs were observed along McKay Creek above Kay Road.

5.2 TERRESTRIAL

5.2.1 Vegetation issues

5.2.1.1 Post-settlement effects on landscape characteristics.

Due to settlement, the pattern of vegetation has changed extensively from reference conditions. The reference landscape consisted of massive expanses of late-successional forest interspersed with occasional patches of early- and mid-successional vegetation where stand-replacement fires had occurred. In the valleys, there were also patchy prairies where frequent flooding occurred. Following settlement, the scenario changed to the current highly fragmented landscape. The valley portion of the watershed is mostly transformed to agriculture. Urbanization has been instrumental in introducing creating fragmented landscapes in the lower reaches of Dairy and McKay creeks, as well as portions of Council Creek. On valley fringes and foothills, the vegetation pattern is highly fragmented between rural residential uses, agricultural uses, and remaining forest. Although fragmentation persists into the mountains, mean patch size increases, and most vegetation is Douglas-fir ranging between 20 and 80 years of age.

5.2.1.2 Potential vegetation management strategies

Given current ownership and landscape patterns, it is infeasible to manage the watershed for large blocks of late-successional forest. Prospects are better for species dependent on small patches of late-successional forest, or on specific late-successional habitat elements. Suitable habitat for these species can be maintained in the LSRs and Riparian Reserves of federal lands. On private lands, potential to provide habitat for these species will depend upon the management emphases of the land owners. Partnership opportunities with these land owners may be available on a case by case basis.

Given current management emphases, both federal and private lands are anticipated to maintain ample habitat for species dependent on early- and middle-successional habitats, as well as edge habitats.

Both federal and private lands are likely to provide some habitat for riparian-dependent species. Forest practice rules for all types of ownerships emphasize retention of a riparian buffer strip. Assuming current management practices, the width of this buffer on private land is likely to remain narrow, and only minimal habitat will be afforded. Some of these stands will develop mature structural characteristics, providing habitat for riparian species that prefer late-successional habitats or habitat features associated with late-successional habitats.

5.2.1.3 Noxious and exotic plants

Ecosystems appear to be losing native species richness due to the invasion of exotic and noxious plants. Much of this threat to native species is on privately owned lands. In some cases, non-native, exotic weeds on these lands can adversely impact federal lands. Adjacent private lands are often so contaminated with exotic/noxious weeds (especially Himalayan blackberry and Scotch broom) that BLM-administered lands can also become easily infested unless preventative measures are enlisted to curtail it from happening. Also, the spread of exotic/noxious weeds along BLM-administered roadways need to be curtailed now so that future management actions will not have a good share of these species to contend with. Examples of such nuisance species include Canada thistle, bull thistle, reed canarygrass, and tansy ragwort. Interior forests in the watersheds do not have weed problems (Chevron et al. 1998).

5.2.1.3.1 Potential strategies for control of noxious and exotic plants

The checkerboard ownership pattern and differing management goals within the watershed make it difficult to have a coordinated program to promote and preserve native plant populations, and limit the spread of exotic plants and noxious weeds. The diversity of native plants on adjacent private timberlands, especially the industrial lands, is very often negatively impacted by the application of herbicides to control competing vegetation. Himalayan blackberry and Scotch broom are two aggressive exotic plant species that are favored by soil disturbing activities, which include road building and timber harvesting. On industrial private lands, however, these plants are often controlled with herbicide applications as a part of their regular vegetation management programs. Herbicide application often results in net loss of native plant diversity, and may have additional detrimental impacts near aquatic systems. Additionally, exotic plants tend to be more aggressive than natives and reinvade treated areas sooner than many native plants, therefore often requiring multiple herbicide treatments to be effective. Native shrub species that are commonly greatly reduced by the invasion of exotic plants include elderberry, cascara, thimbleberry and salmonberry. Loss of these species has the potential to impact the distribution or abundance of wildlife species such as band-tailed pigeon, Swainson's and varied thrushes and black-tailed deer.

Success of eradication efforts will vary. Some species, such as Himalayan blackberry, are ubiquitous within the watershed, and we can only hope for localized success in eradicating such species.

Preemptive action can be taken to detect potential problem plants and prevent their introduction to the watershed. The giant reed (*Arundo donax*), for example, has created substantial problems in California and is sold as an ornamental here.

Concerns have been voiced that *Arundo* might become a nuisance weed in the Tualatin Valley.

5.2.1.4 [BLM only] Potential management strategies within the Riparian Reserves

Watershed-wide, the amount of habitat available to riparian-dependent species is severely limited. For that reason, any portion of the Riparian Reserves affording habitat for riparian-dependent species should be retained in a condition where they fulfill that function. These areas, and those with potential to provide habitat, should be managed to promote the development of desirable habitat features. Similarly, late-successional habitat is severely deficient in the watershed. Thus any riparian areas that afford such habitat, or are capable of developing such characteristics, should be retained. In some cases, thinning and projects to create snags and down wood may help in development of these important habitat characteristics.

Portions of the Riparian Reserves within the watershed are allocated around areas of steep, unstable terrain. Due to the risk of landsliding and sediment contributions to streams, harvest activities may not be advisable in such areas.

5.2.2 Species and habitat issues

5.2.2.1 Factors affecting the distribution of sensitive species.

Timber operations and their associated roads have had a significant effect upon the character of the stands within the watersheds. Consequently, the landscape of these watersheds is largely made up of fragmented second-growth conifers that are frequently deficient in habitat requirements for sensitive plant species (preliminary plant inventory results from 1978 BLM vascular plant surveys).

BLM-administered lands are found in a checkerboard pattern in the watersheds. Forest fragmentation and loss of native plant diversity is far greater on private lands due mainly to consistent logging and associated road building and the draining of wetlands. Noxious/exotic weed invasions on these disturbed lands have also increased immensely, thus compounding the loss of natural habitats. Since habitat loss for species of concern is an important factor in this watershed, it is of increased importance that remaining habitats on federal lands be maintained.

Many sensitive species are dependent upon late-successional habitat or specific features associated with late-successional habitat. Such habitat will continue to be limited in the watershed. Most appropriate habitat will eventually be developed in the Big Canyon LSR, and in strips along streams in federal Riparian Reserves. Depending upon management policies, suitable habitats may be developed in riparian areas on private lands. Thus, species dependent on late-successional habitat are likely to be restricted to these lands. The characteristics of these areas will tend to favor species with small home ranges. Habitat for species dependent on mid- and early-successional conditions is expected to remain abundant.

Current levels of snags and down wood are greatly diminished from reference conditions. Due to the lack of mature and old growth forest, few snags and little down wood now exists, and future recruitment potential is limited for a number of years to come. Most such potential is in assorted patches of mature timber on BLM and private lands. In the case of private lands, most stands capable of providing snags and down wood are located on headwater portions of the watershed. Such potential is not expected to increase on private lands, as forest harvest continues. However, Riparian Reserves and other protected riparian buffers are expected to lead to increased levels of down wood in riparian zones. Additionally, leave-tree requirements on federal matrix lands are likely to result in continued supplies of snags and down wood. Active management efforts to increase levels of snags and down wood would benefit many species, including primary cavity nesters such as woodpeckers and secondary cavity nesters such as bats, flying squirrels and saw whet owls.

Due to loss of habitat, the populations of many species of concern have diminished. The spotted owl, for example, is assumed to be eradicated from the watershed due to lack of habitat. The bald eagle and the pileated woodpecker have been diminished. The red tree vole is either extirpated or diminished.

The marbled murrelet is not known to have utilized the watershed. However, there is potential murrelet habitat here. Much less of such habitat exists than under reference conditions.

Appendix J2 of the Northwest Forest Plan and Management Recommendations for Fungi, Version 2.0, September 1997; and present protocols for category 1 and 2 lichens and bryophytes tell what the ecosystem requirements are for species listed in these documents. The influences and relationships of these species and their habitats with other natural or anthropogenic processes are often fragile. The Salem District Record of Decision (ROD) and the Salem District Resource Management Plan (RMP) require certain protection and management procedures be followed for an array of 4 categories of Survey and Manage species. BLM manual 6840 gives details on the protection and management of Bureau Sensitive, Assessment, and Tracking species. Those species potentially found in the Dairy-McKay watershed are listed in Table 1-3 and Sections 3.1.5.1, 3.1.5.2, and 3.2.2.1.2.

The population of game species appears to be stable, with possible minor increases in elk and waterfowl. The major concern at present for some of these species is not depletion, but rather potential conflicts with human land uses. Large elk populations, for example, can create damage to farm and rural residential properties. Although ODFW has found it necessary to implement elk abatement programs near Scappoose, the elk populations in the Dairy-McKay watershed to not appear to be creating a substantial conflict with human interests (Thornton, ODFW, personal communication).

The ownership pattern restricts creation of a uniform habitat management strategy for sensitive species. Habitat management partnerships could potentially be formed with the entities identified in the recommendations related to noxious weeds (Chapter 6).

5.2.3 Forest resources issues [BLM-specific]

5.2.3.1 Management of snags and down wood

Based on stand age, BLM lands in the Dairy-McKay Creek watershed likely have low levels of snags and down wood. In many instances, it will be appropriate to increase the amount of down wood by placement of fresh down Douglas-fir trees. When leaving these trees, the potential impacts to the residual stand from the Douglas-fir beetle should be considered. In westside forests, when there are more than three windthrown Douglas-fir trees per acre greater than 12 inches DBH, infestation and mortality of standing live Douglas-fir trees can be expected (Hostetler and Ross, unpub.). For every two down Douglas-fir trees per acre greater than 12 inches DBH, beetles will likely attack one standing live Douglas-fir tree. Not all beetle attacks will result in tree killing, however. As a general guideline, the number of standing Douglas-fir trees killed in the years following wood placement will be about 60% of the number of fresh down Douglas-fir trees added to the forest floor. However, there is some new information indicating that the number of trees killed may be as low as 25%. Tree vigor is an important factor determining whether a given tree can withstand beetle attack. Trees infected with root disease are especially at risk from beetle-related mortality. It is also important to note that the threat to the surrounding trees is much less when the down trees are exposed to direct sunlight as opposed to being shaded. Beetle attacks and subsequent brood production from exposed down trees are substantially lower than when they are shaded. Wood placed between July and September is also less likely to lead to beetle infestations.

There are sites, particularly in LSRs and Riparian Reserves, where moderate levels of tree mortality due to Douglas-fir beetle activity can be beneficial. Such mortality increases diversity of stand type and structure. These potential benefits should be taken into account on a site-specific basis when placing down wood.

5.2.3.2 Laminated root rot

Damage caused by *Phellinus weirii* root rot will likely be higher in most managed stands than in natural stands. Most of the harvested lands in the watershed have been reforested with Douglas-fir, which is readily infected and killed by this root disease. Once young Douglas-fir trees reach about 15 years of age, disease centers become apparent and root-to-root spread occurs from the original infection site. On-the-ground surveys in commercial-sized stands in this area are consistent with the findings of Thies and Sturrock (1995), which have shown that Douglas-fir volume production in *P. weirii* root rot centers is less than half of that in healthy stand portions. Disease centers are believed to expand radially at the rate of about one foot per year (Nelson and Hartman 1975) and losses in diseased stands may double every 15 years (Nelson et al. 1981). It is generally not recommended to commercially thin in stands of highly susceptible species, such as Douglas-fir, when disease is present in 20 percent or more of the stand (Thies and Sturrock 1995). High levels of *P. weirii* infection (more than 25 percent of the area in disease centers) are of special concern when considering commercial thinning, especially if the disease centers are not well defined. Specific locations have been identified on photographs, but treatments will be performed on a site-by-site basis.

5.2.3.3 Management of hardwood stands

A sizeable but indeterminate portion of the watershed is in the mixed conifer/hardwood or pure hardwood stand condition. Red alder is by far the most abundant hardwood. Many of these sites once supported western redcedar and other conifers, but because of site disturbance during past timber harvesting activities and inadequate conifer reforestation, alder has become a dominant stand component. Some of these sites are capable of supporting conifers at this time. Others are best left in alder for a while to help relieve soil compaction and increase the site nitrogen level. Some sites, such as wet areas, are probably best left in alder and not intensively managed to restore full conifer stocking. Alder domination of conifer-producing sites represents a potential loss of timber volume production. Over time, the difference in volume production between Douglas-fir and hardwood stands is expected to become increasingly larger.

The proportion of the watershed dominated by red alder has increased in comparison to the reference conditions as a result of ground disturbance from timber harvesting and associated road building activities. Historically, most alder was probably restricted to areas along streams on lower slope positions. Alder currently dominates many upland areas where soils have been disturbed, and is very prevalent along roads. Alder aggressively competes with young conifers for growing space.

5.2.3.4 Achievement of late-successional goals in Big Canyon

Late successional goals in Big Canyon will be determined as part of a Late Successional Reserve Assessment (LSRA). In order to facilitate the management of this LSR, completion of this assessment should be achieved.

5.2.3.5 Management on Connectivity lands

According to the Salem ROD, Connectivity lands are to be managed on a 150-year rotation. Stands on Connectivity blocks in the Dairy-McKay watershed currently range from 60 to 80 years in age. Harvest of some of these stands is necessary for forest regulation and to derive desirable uneven-aged characteristics. Some opportunities might exist for thinning within the Connectivity allocation, provided that such thinning has demonstrable benefits to stand health and/or structural characteristics.

5.3 SOCIAL

5.3.1 Issues related to human uses

5.3.1.1 Agriculture

The amount of farmland is expected to decrease slowly within the watershed. In its comprehensive plan, Washington County recognized the importance of agriculture to the quality of life in the region and designated Exclusive Agricultural Use Zones. These zones protect most of the lands presently in agriculture. Most losses to agricultural land are expected to occur on lands within the Urban Growth boundary, or on the urban fringe.

Agricultural operations impact watershed resources, often creating conflicts with other beneficial uses within the watershed. Most particularly, they are the greatest single use of surface water resources. Operations also can contribute to water quality problems, creating potential conflicts with fishery and recreational resources. With improved practices, negative impacts and conflicts are being reduced. Many of these improvements have been achieved with the assistance of the Farm Service Agency (FSA), the Natural Resources Conservation Service (NRCS), and the Washington County Soil and Water Conservation District (SWCD). Through implementation of farm conservation plans and other programs, farmers in conjunction with these agencies have been able to reduce soil loss, water consumption, and inputs of sediments, nutrients, and other pollutants to streams. Since many farms in the watershed operate without fully utilizing these services, further opportunities for improvement exist within the watershed. However, these agencies and programs lack the funding to fully meet the demand in a timely fashion.

Although total agricultural production is a substantial portion of the watershed economy, the results of the 1992 agricultural census indicate that many farms operate on a slim profit margin. This should be taken into account when implementing new programs to address conflicts with other beneficial uses in the watershed.

5.3.1.2 Timber

Timber operations within the watershed are expected to remain constant or produce more wood in the near term[1]. Many of the forest resources that were depleted in the first half of the century (both through timber harvest and through fire) have regrown to harvestable age, indicating that abundant opportunity exists for increased logging within the watershed. This opportunity has been reflected in the increased timber harvest that has occurred in the watershed since 1990. The large private ownership within the watershed, coupled with diminished output from public lands, indicates that the watershed may be an important supplier of timber in the present and near future.

With increased harvest comes a renewed potential for conflicts with other beneficial uses of the watershed. In the past, timber harvest contributed to significant problems related to erosion and sedimentation, leading to channel changes and diminished fishery resources. Reductions of wildlife populations dependent on late-successional and riparian habitats have also occurred due to the history of disturbance within the watershed. With the improved forest practice rules currently in effect, riparian and stream problems related to timber harvest are expected to be lower than past levels. However, habitat problems for late-successional species are expected to persist.

In order to minimize conflicts with other beneficial uses, future timber operations should consider maintenance of lands in multiple stages of development. As lands within the watershed are seriously deficient in late-successional habitat, enhanced protection of late-successional habitat should be encouraged.

As with private lands, most BLM stands are currently entering harvestable stages. Thus, opportunities for enhanced timber production lie upon such lands. However, because of the differing objectives and practices of federal and private lands, the greatest opportunities for maintenance of sensitive habitats lie upon federal lands.

5.3.1.3 Urban uses

Increasing population is probably the greatest change creating a demand on watershed resources. As population grows, demands for housing space, recreation, and workspace increase, as well as demands on water and contributions of wastewater. Population trends in Washington County indicate that these demands and pressures will consider to persist into the next century. Given current urban growth boundaries, the bulk of these demands will be concentrated along the urban corridor in the southern portion of the watershed. Most construction in response to this demand will consist of infilling within present urban growth boundaries. Within these regions, impervious surfaces will increase. Potential hazards from urban runoff will also increase. As population grows, additional conflicts can be expected between urban and agricultural interests, and pressure to expand the urban growth boundary will be increased.

Rural residential populations can also be expected to increase. Many of these increases will be in alluvial plains near streams, increasing potential hazards to stream resources. Additional concerns as development interests buy rural lands are that these interests will provide pressure to governmental agencies to allow subdivision of these lands.

5.3.1.4 Rural interface

Rural interface problems are hard to gauge. Many BLM parcels are not easily accessible to the public and thus do not pose a problem. However, parcels that are readily accessible by road have experienced dumping problems in the past. Nearness to urban areas many exacerbate this problem. If the magnitude of the problem is serious enough, further action may be necessary to restrict access to BLM lands.

BLM activities could potentially impose conflicts with nearby residential uses. Parcels within 1/4 mile of land zoned for residential parcels less than 5 acres in extent are listed in Appendix 4. Additionally, some BLM parcels are located where they are readily visible from residential lands along East Fork Dairy Creek and McKay Creek. Landowner considerations should be taken into account when planning harvest in these parcels.

5.3.1.5 Recreation

Recreational opportunities in rural portions of the watershed are mostly dispersed. Hiking and hunting take place on public lands and assorted private timberlands in the Tualatin Mountains. Additionally, hiking and bicycling activities exist on the Banks-Vernonia linear trail, and some developed roads. Fishing occurs along streams.

The availability of public lands for these activities is limited by access. Many BLM parcels either do not have public road access or have such access closed by landslides. Performance of recreational activities on such lands are limited to the more ambitious recreationalists. One notable exception is the parcel adjoining Uble Road, which has trails commonly used by the nearby Girl Scout camp for horseback riding.

[1] Based on stand characteristics, and harvest policies on federal lands. No timber economists were consulted.

Several golf courses exist in the watershed. One, the Pumpkin Ridge golf course, is located in a rural section of the watershed north of North Plains. The others are in urbanized portions of the watershed. The primary impact of these recreational sites would be created by inputs of fertilizers to aquatic systems. The actual extent of such effects are unknown.

A model plane flying field is located off of Mountaindale Road near Highway 26. Potential impacts of this recreational activity are unknown.

Recreational opportunities within the urban portions of the watershed are generally more intensive. Many such activities are centered around indoor uses and have watershed impacts similar to those for other urbanized activities. Where concentrated near streams, outdoor activities may contribute to channel degradation and sedimentation. Additionally, maintenance of recreational areas, such as parklands and golf courses, may increase inputs of nutrients and pollutants to streams.

5.3.2 Cultural Resources

Based on the history of Native American occupancy, there is a likelihood that significant cultural resources could exist in the valley portion of the watershed. Tribal specialists were consulted, but did not identify any such resources.

5.3.3 Road-related issues

Road-related concerns are also discussed in sections related to erosion, hydrology, stream channel, and aquatic habitat.

The highest risk for road-related slope failures occur on steep lands in the Tualatin Mountains. Middle portions of McKay Creek, in particular, have had a particularly high incidence of road related slope failures. However, other such failures have been distributed on other roads in the watershed. These failures potentially create opportunities for accelerated sediment inputs to streams. Such seems to have been the case in the McKay Creek slide near the Pacific Rock Products quarry, as well as several smaller slides.

Stream crossings potentially create migratory hazards to anadromous fish. Additionally, insufficiently sized culverts may lead to road washouts, contributing to sedimentation problems. During a recent survey, Washington County found a majority of culverts to be inadequate, either because of migratory or size concerns.

Road surfacing led to a need for rock pits. Two of these are located near McKay Creek: The Pacific Rock Products quarry near the confluence with the East Fork of McKay Creek, and the Washington County quarry near Jackson Creek. The Van Aken quarry, in the Sadd Creek subbasin, is another large rock mining operation. These sites may pose sediment risks to nearby streams. Additional quarries may exist in the watershed.

5.4 DATA GAPS

During preparation of this watershed analysis, several data gaps were identified. Data collection in these areas will provide potential benefits to management, planning, and restoration efforts.

Erosion Processes

- Magnitude and location of mass-wasting processes. This watershed analysis supplied slope-based indicators of high landslide potential and locations of several notable landslides. A comprehensive landslide inventory based on aerial photography and field visits would enhance our knowledge in this area, as well as determining present and potential sediment sources.
- Magnitude and location of sheet, rill, gully, and bank erosion. This watershed analysis identified stream reaches and subwatersheds where such erosion was observed or would be likely. Site-specific field surveys and quantitative modeling would enhance our knowledge of these processes in the watershed.
- Magnitude of erosion reduction effected by implementation of specific BMP's and relative effectiveness of these BMP's.
- Riparian conditions in forested lands and impacts of forestry near streams. Although this watershed analysis noted improvements in Oregon Forest Practice Rules that reduced erosion, it did not address the adequacy of these rules and current enforcement practices to attain erosion-control and water quality objectives.

Hydrology and Water Quantity

- Discharge characteristics at ungaged locations in the watershed. Watershed-wide flow modeling calibrated with field observations would facilitate determination of locations of seasonally inadequate flow.
- Adequacy of current instream water rights to

protect aquatic life and other instream beneficial uses. This report identified existing instream water rights, but did not attempt to determine whether these rights provided adequate protection for aquatic resources. More intensive field study would be necessary to answer this question.
- The best locations for potential purchases of instream water rights.
- The extent of illegal water diversions.

Stream Channel

- Field verification of GWEB channel types. Field study would also provide insights on characteristics not visible from maps and photography, and would aid in restoration planning. Additionally, channel types should be updated to reflect ongoing changes in the GWEB channel typing methodology.
- Ongoing changes in channel characteristics. Field study aimed at detection of current channel migration, widening, and entrenchment would aid in planning efforts.

Water Quality

- Location of inadequate septic systems in the watershed.
- Specific sources of high aquatic phosphorus levels on Waibel Creek.

Aquatic Species and Habitats

- Macroinvertebrate distribution. Comprehensive macroinvertebrate surveys would enhance understanding of water quality and ecological characteristics of the watershed, and would help to delineate potential trouble spots.
- Distribution of fish habitat. In the 1990's, BLM conducted surveys over substantial portions of East Fork Dairy Creek and McKay Creek. More localized surveys have been conducted by ODFW, Pacific University, OGI, and USA. A better understanding of the quantity and quality of habitat for salmonids and other species of interest would be gained if these surveys were supplemented by a comprehensive habitat survey.
- Amount and distribution of salmonid spawning. Redd counts and spawning surveys would be beneficial to determine actual usage patterns by salmonids.
- Population and distribution of amphibian species. Comprehensive amphibian population surveys would help determine the distribution of sensitive species and the potential impacts of habitat loss and exotic species upon native amphibians.
- Population and distribution of sensitive species dependent on riparian and wetland habitats.
- Historic extent of wetlands. This report recorded the extent of wetlands recorded on 1870's era survey maps and noted that this estimate was likely to be low. Another estimate might be developed based on hydric soils.
- Present extent, types, and condition of specific wetlands. Analysis of present wetland extent was based on surveys performed as part of the National Wetlands Inventory (NWI). Additional information could be gained if the NWI delineation were refined using current aerial photographs and field research. Field study would also help to determine the condition of specific wetlands and locate priority sites for restoration.

Vegetation

- Amounts and distribution of sensitive botanical species. These include bryophytes, lichens, and fungi, as well as vascular plants. Comprehensive botanical surveys would facilitate planning efforts for these species.
- Canopy cover and density of riparian stands.

Terrestrial Species and Habitats

- Distribution of snags, large woody debris, and other late-successional habitat characteristics used by species dependent on these characteristics. Based on stand age and size, this report concluded that these habitat characteristics are uncommon in the watershed. Field surveys would be useful to verify this conclusion and find locations of such habitat characteristics.
- Distribution of sensitive species dependent on late-successional habitat characteristics. Population surveys would contribute to management efforts for these species.

Human Uses

- Potential mitigation and funding sources for mitigation of rock pit sites
- Size and condition of culverts in eastern portion of the watershed. Complete bridge inventory, including specifications. Ability of culverts to withstand major floods.
- Specific roads needing repair or closure.
- Extent of dumping on BLM and private lands within the watershed
- Historically, railroads and logging roads were built on sites throughout the Tualatin Mountains. Many of these "legacy roads" may continue to provide erosion and/or sedimentation hazards. However, determination of the locations of these roads, as well as potential mitigation opportunities, was beyond the scope of this report.

Chapter 6: Recommendations

Watershed needs and opportunities are most effectively addressed by a consistent, cooperative effort between landowners and government agencies. In keeping with that principle the following recommendations are intended as general guidelines for cooperative efforts that can be undertaken to achieve watershed objectives. (Recommendations specific to BLM lands are given later in this chapter.) These recommendations are not intended to mandate what private landholders should do with their own land, but instead to identify potential opportunities for improvement of conditions within the Dairy-McKay watershed. Implementation of these recommendations is completely voluntary on the part of the private landowner. Opportunities will be available through cooperation with private landowners to create partnerships to implement these recommendations. As the nexus of many different interests, the Tualatin River Watershed Council plays a vital role in facilitating these partnerships.

The nomenclature for these recommendations was designed with this concept of partnership in mind. Three groups have been identified. The actual implementation of these recommendations and objectives is performed by a large and varied group of individuals, grassroots organizations, and corporations. They voluntarily organize educational activities, donate material, contribute labor and expertise, and manage their lands to achieve desirable watershed objectives. Although the people in this group represent diverse interests, they work toward similar beneficial objectives, and here they are described collectively as **partners**[1]. Another group, that of governmental **agencies**, has specific duties to achieve watershed objectives. Although they are also important partners in the watershed restoration efforts, when performing their official duties they will be referred to as agencies. Finally, the **Tualatin River Watershed Council** acts as facilitator to promote implementation of these recommendations. In this role, the council acts to coordinate efforts between partners to achieve beneficial watershed objectives.

Success of many programs delineated within these recommendations is contingent upon funding. There are several sources of expertise and funding for projects on private lands that could be used for the opportunities identified below. Oregon Department of Fish and Wildlife and state Restoration and Enhancement funds are available for restoration of riparian and stream habitat. The Natural Resources Conservation Service and the Washington County Soil and Water Conservation District have access to federal funds for improvement, particularly of agriculturally related problems in the lower watershed. The U.S. Fish and Wildlife Service, through its Partners for Fish and Wildlife program, also funds wildlife habitat restoration and improvement projects for wetland, riparian, and instream areas on non-federal lands. This availability of state and federal

[1] It should be noted that the Tualatin River Watershed Council is engaged in many types of partnership activities. Involvement in these partnership activities does not obligate a person or corporate entity to become a partner in the sense used in this document, except to the extent that the person or entity chooses to become involved.

Table 6.1. Priority sites for preservation, restoration, and renovation of riparian and wetland sites.

Site	Type of activity	Rationale
East Fork Dairy Creek (north of Greener Road)	Riparian preservation Riparian restoration Channel restoration/enhancement	Historically good fish populations indicate that remaining habitat should be preserved, and that restoration will be effective.
East Fork Dairy Creek (Mountaindale to Greener Road)	Riparian restoration	Adjacent to important fish bearing reach. Has gravel substrate. Indicates good potential for expansion of salmonid rearing.
West Fork Dairy Creek (Williams Creek to mouth)	Riparian restoration	Most extensive depletion of riparian vegetation. Also has extensive bank erosion.
McKay Creek (North Plains to East Fork)	Riparian restoration	Riparian vegetation often constituted by thin, sparse tree layer.
Jackson Creek (near McKay Creek)	Riparian restoration	Virtually no vegetative cover, channelized stream.
Council Creek	Riparian enhancement Wetland enhancement (ponds)	Very little riparian vegetation. Ponds could be enhanced to provide better wetland habitat.
Cedar Canyon	Purchase of land/conservation easements Wetland preservation Wetland enhancement	One of the best remaining examples of wetland habitat in watershed.
West Fork Dairy Creek (Lousignont area)	Wetland enhancement/restoration Purchase of conservation easements	Historically and currently region with greatest amount of wetlands. Current wetlands seriously degraded with *Phalaris*.
McKay Creek near East Fork McKay Creek	Landslide stabilization/ culvert replacement	Provides a sediment hazard to streams.
Jackson Bottom (Portion within Dairy-McKay watershed)	Wetland enhancement	Portion owned by Jackson Bottom Preserve, potentially expediting enhancement efforts.
Waibel and Storey creeks	Riparian enhancement Improvement of waste management	Very high phosphorus levels, and known locations of poor waste management and nearstream soil erosion.

funding should encourage private landowners to join in the effort to improve the Dairy-McKay watershed ecosystem. Furthermore, the Watershed Council and various agencies should pursue additional funding to address the identified needs within the watershed. Through the watershed analysis process, several stream reaches and wetland areas were identified as priorities for preservation and restoration activities priorities were generally based on the degree of degradation and the potential to restore specific beneficial uses (e.g., potential for salmonids to utilize improved habitat). Areas with relatively good habitat were earmarked for preservation.

AQUATIC

Erosion issues

Problem: Soil disturbing activities on steep and unstable forested lands lead to increased hazards for surface erosion, mass wasting, and sediment delivery. Roads are a major contributor to erosion. Stream crossings facilitate sediment delivery.

Solution Strategy: Erosion control efforts in the mountainous portions of the Dairy-McKay watershed would best be concentrated in areas of steep slope and subbasins with high densities of roads and stream crossings. Ideally, total road mileage should be reduced within such areas. Avoidance of soil disturbing activities on steep and unstable lands would also reduce erosion.

Specific Recommendations.

- Land owning partners in the mountains are encouraged to implement the following road-related practices: Avoid building new roads on steep and unstable lands. Evaluate currently existing roads for usefulness to current management activities. Where feasible, decommission or obliterate unnecessary or undesirable roads by pulling back sidecast material, removing culverts, outsloping where needed, subsoiling to restore infiltration, and revegetating the road surface and other disturbed areas with native species. Priority roads for obliteration include those built on midslopes with sidecast construction. Subwatersheds where these recommendations are particularly applicable include **McKay Creek**, **Brunswick Canyon**, **McKay - Neil Creek**, **East Fork McKay Creek**, and **Williams Creek**.

- Drainage-related erosion will be reduced if land owning partners and agencies with road maintenance authority maintain or improve road drainage by cleaning culverts, replacing decaying culverts, and installing downspouts on culverts that have outfalls at a substantial distance above the hillslope. Any culverts that are installed should be designed to withstand the 100-year flood event.

- In order to reduce erosion and sediment contribution to streams, landowning partners and agencies with road maintenance authority should maintain a vegetative cover on drainage ditches.

- Land owning partners and agencies with road maintenance authority can reduce sediment contribution to streams by implementing the following practices where high densities of roads and stream crossings exist: Decommission unnecessary roads. Survey remaining roads for areas with high risk of erosion from cutslopes, fillslopes, and road treads. Minimize such hazards, using methods such as outsloping and endhauling sidecast materials. Locate culverts or drainage dips to avoid excess accumulations of water in ditches or on road surfaces. Minimize connectivity between drainage ditches and streams to minimize sediment delivery potential. These recommendations are particularly applicable to the following subwatersheds: **Williams Creek, Mendenhall Creek, Whitcher Creek, Garrigus Creek, West Fork Dairy - Kuder Creek, Middle West Fork Dairy Creek, Denny Creek, Sadd Creek, and Murtagh Creek.**

Problem: Sheet, rill, and gully erosion from fields and streambank erosion is widespread in the Tualatin Plain. The greatest problem from surface erosion occurs when soil is inadequately protected from rainfall. Bank erosion is greatest in areas of impaired riparian vegetation. Where riparian vegetation is lacking, accelerated sediment delivery to streams also occurs.

Road drainage ditches provide channels that facilitate transport of eroded sediments and associated pollutants from fields, and delivery of these substances to streams.

Systematic methodologies to assess the effectiveness of Voluntary Water Quality Farm Plans and agricultural Best Management Practices (both individually and in combination) are lacking.

Solution Strategy: Effective erosion control in the valley portion of the watershed will emphasize riparian restoration, residue management, cross-slope farming, rotations with sod-building crops, cover crops, filter strips and grassed waterways on agricultural operations. The former objective is most efficiently achieved through voluntary efforts spearheaded by the NRCS/SWCD. These agencies have a long history of working together with farmers to reduce soil loss. Additionally, these agencies are able to offer economic incentives and cost-sharing programs to implement Best Management Practices. When developing conservation plans, erosion predictions should be based on the most erodible slopes rather than average slopes in a field. Implementation of a systematic methodology and database to keep track of specific components of Water Quality Management Plans would assist agency sources in refining future prescriptions.

Specific Recommendations:

- NRCS/SWCD and other agencies should continue to promote implementation of Best Management Practices by agricultural interests. NRCS/SWCD should determine locations in the watershed where BMP's are least often used, and focus efforts on these areas. Together with the Tualatin River Watershed Council and the Farm Bureau, NRCS/SWCD should determine outreach measures to improve land owner interest in implementation of BMP's. These entities should actively seek funding to provide expanded assistance toward these objectives. They should pursue greater funding for cost-share programs and incentives to retain greater widths of riparian vegetation. Local governmental agencies should request a greater role in designing programs such as the Conservation Resource Enhancement Program (CREP), so that these programs best meet local needs.

- Public agencies responsible for road maintenance should maintain a vegetated lining in road ditches. Similarly, land owning partners will benefit from reduced erosion if they incorporate a vegetated design in drainage ditches on their property.

- When designing conservation plans, NRCS and SWCD should keep a database of practices implemented in each plan, and enhance monitoring of farms under such plans to determine the effectiveness of various prescriptions (This will partially fulfill Tualatin River Action Item 6A.). As part of this effort, they should design a standardized format for the database so that information collected by different agencies can be easily interchanged. These recommendations are particularly applicable to **all agricultural subwatersheds.**

- The Tualatin River Watershed Council should continue to coordinate efforts to restore and enhance riparian vegetation. As part of this effort, the Council should continue to coordinate programs with community groups to plant riparian vegetation. The Council, together with the NRCS and SWCD, should assist landowners with restoration efforts. From an erosion standpoint, the areas of highest priority for revegetation include: the **West Fork of Dairy Creek between Williams Creek and the confluence with Dairy Creek, East Fork Dairy Creek between Murtagh Creek and the confluence with Dairy Creek, McKay Creek East Fork McKay Creek and North Plains, McKay Creek between Evergreen Road and Waibel Creek, and Jackson Creek near the confluence with McKay Creek** (see Appendix 6).

- The Tualatin River Watershed Council and its partners should adopt a policy to protect all currently existing riparian vegetation. As part of this policy, they should advertise currently existing incentives and cost-share programs to remove riparian lands from agricultural production. Where these programs provide inadequate incentive for riparian restoration, the Tualatin River Watershed Council and its partners should work with the federal and state government to provide additional incentives.

- The NRCS and SWCD should continue efforts to work with agricultural landowners to remove prohibited conditions under the Tualatin River Subbasin Agricultural Water Quality Management Area Plan (OAR 603-95, listed in Appendix 3).

Problem: In urban areas, increased surface runoff from impervious surfaces leads to contributions of pollutant-laden sediments to stream systems. Construction activities contribute to erosion and potential sediment delivery. Increased peak runoff potentially causes increased downstream erosion.

Solution Strategy: Management strategies should focus on reduction of surface runoff, control of sediment sources, and settling of suspended sediments.

Specific Recommendations:

- Partners and agencies responsible for urban portions of the watershed should continue to promote use of urban Best Management Practices. Use of these practices should not be limited to areas within the urban growth boundary, but should extend to all areas with urban characteristics. These partners should conduct educational efforts that inform the public on BMP's and also stimulate public interest in implementation of these BMP's by outlining desirable, achievable environmental goals. A methodology should be formulated to measure progress toward achievement of these goals, and the public should receive regular progress reports. Partners should promote landscape design that reduces direct urban runoff to streams. Agencies should maintain current restrictions on construction near streams, and currently mandated buffer zones. These recommendations are particularly applicable to **Dairy Creek, North Hillsboro, Lower McKay Creek, Middle McKay Creek, Council Creek and Waibel Creek** subwatersheds.

Hydrology and water quantity issues

Problem: Wetland and floodplain area is greatly diminished from historical levels. This has resulted in loss of hydrologic regulation of flows.

Solution Strategy: The most effective policy given current constraints is to protect existing floodplain and wetland resources, and to prevent encroachment of activities that are incompatible with floodplain and wetland function. Where incompatible uses do not exist, there may be opportunity to restore the functionality of degraded wetlands. Opportunities for wetland enhancement may be available on lands recently acquired by the Jackson Bottom Wetlands Preserve. Additionally, there may be partnership opportunities with sympathetic landowners to create or re-establish wetlands where they do not currently exist.

Specific Recommendations:

- Planning agencies should restrict further residential and industrial development within the 100-year floodplain.

- The Tualatin River Watershed Council, partners and NRCS/SWCD should sponsor a study to determine priority sites for preservation or restoration of historic floodplain and wetland function. For each site, appropriate protection, restoration, or enhancement strategies should be identified. Information gained in this study should be systematically maintained in a database, where it can be referenced for future funding opportunities.

- Partners and appropriate agencies should acquire property or habitat conservation easements to protect or expand existing wetlands. They should also evaluate opportunities for land acquisition with which to create new wetlands. If wetland creation appears to be a viable option, they should purchase lands for this purpose. The greatest potential for restoration of historic wetland function lies in traditional wetland sites in the **Lousignont Canal, West Fork Dairy - Cedar Canyon, Lower West Fork Dairy Creek, Bledsoe Creek, and East Fork Dairy Creek** subwatersheds.

- The Tualatin River Watershed Council and its partners should institute programs to restore functionality to degraded wetlands. This should include replacement of reed canarygrass and other exotics with native vegetation. The subwatersheds with the greatest amount of eligible wetlands include **Lower West Fork Dairy Creek, Lousignont Canal, West Fork Dairy - Cedar Canyon, and McKay-Tualatin confluence.**

- Agencies and partners should conduct post-project monitoring to determine the success of wetland restoration efforts.

Problem: Diversions of streamflow have diminished summer flows far below reference levels. Over much of the year, surface flow appears to be insufficient to support all beneficial uses. Current instream water rights may be inadequate to protect resources.

Solution Strategy: Water conservation is a necessary part of any strategy designed to optimize water supply for all beneficial uses. As irrigation is the largest use of surface water within the watershed, conservation efforts would benefit greatly if agriculture employs technological solutions to minimize waste during irrigation.

During formulation of its action plan, the Tualatin River Watershed Council considered the acquisition of additional water rights to supplement current instream water rights. If the decision is made to acquire supplementary instream water rights, consideration should be given to the OWRD instream leasing program. Several considerations should go into any decision to acquire instream water rights. Seniority, of course, is a prime consideration. However, location of these water rights is also important. In order to protect cold-water fishery resources, any additional water rights purchases should protect instream flows in the Tualatin Mountains and the upper portion of the plain, where most summer rearing is likely to occur. Downstream of these locations, enhanced flow will have some value for thermal moderation of streams, but is unlikely to provide direct benefit to salmonids outside of migration periods. Other native fish species, such as lampreys, would benefit from resulting improvements in water quality.

Specific Recommendations:

- TRWC, partners, and agencies should encourage irrigation water management, including the use of technological soil moisture sensing devices and the conversion of sprinkler to drip systems on appropriate crops.

- TRWC, partners, and agencies should conduct a study to determine the adequacy of current instream water rights to provide adequate conditions for fish and other aquatic life. If current instream water rights are found to be inadequate, locations of greatest need for supplementary water rights should be noted. Priority for water rights acquisition should be given to the most senior rights available at these locations. When acquiring water rights, strong consideration should be given to use of the OWRD instream leasing program.

Stream channel issues

Problem: Stream channels are severely deficient in large wood. This has limited the development of pools, which provide essential habitat for fish and other aquatic life. Little potential exists for recruitment of large wood to streams.

Solution Strategy: Long-term development of large woody debris recruitment potential should be supplemented by short-term tactics. Potential elements of this strategy include re-introduction of conifers to hardwood stands, thinning within riparian zones to promote development of tree mass, and artificial placement of instream structures. Location of these restoration activities will depend on management objectives. Channel structure throughout the watershed would benefit from placement of large wood. However, wood placement to improve habitat for salmonids would be more effective in the mountains and nearby areas than in lower reaches in the Tualatin Plain. Effective channel restoration strategy throughout the watershed will focus on preservation of existing channel characteristics at relatively high quality sites.

Specific Recommendations:

- As an interim measure, partners performing stream restoration should place large wood in channels, and construct instream structures to create pools in degraded habitat with high fisheries potential. Restoration projects should include substantial post-project monitoring to determine the effectiveness of restoration techniques. Channel structure throughout the watershed would benefit from this recommendation. Sub-basins where placement of large wood would have the greatest benefit for salmonids are listed in the aquatic species and habitat section.

- Landholding partners should manage riparian areas to develop late-successional characteristics so that they can eventually develop large wood for potential delivery to streams. This can include re-introduction of conifers to hardwood stands and some thinning within riparian zones.

Water quality issues

Problem: In many portions of the watershed, sediments are delivered to streams at levels well above reference conditions. These sediments often carry adsorbed pollutants.

Solution Strategy: Strategies to combat sedimentation are described under the erosion section.

Specific Recommendations:

- NRCS/SWCD should continue efforts to expand implementation of agricultural Best Management Practices to reduce sediment discharge to streams (see under Erosion).

- Agencies, partners, and TRWC should work together to restore riparian buffers (see under Erosion).

- Landowning partners and agencies with road maintenance responsibility should minimize connectivity of road drainage ditches to stream channels (see under Erosion). Where necessary, they should build a sediment settling system to detain runoff prior to stream entry.

Problem: High levels of bacteria and ammonia have adversely impacted streams within the watershed. In some cases, inputs of these constituents have caused streams to be listed under section 303(d) of the Clean Water Act.

Solution Strategy: The management strategy for problems related to bacteria and ammonia nitrogen should focus on keeping animal and human waste away from aquatic systems. Successful nitrogen management also relies on effective fertilizer management.

Specific Recommendations:

Agencies should intensify efforts to identify and improve faulty septic systems near streams. In order to facilitate improvement of these systems, homeowners should be offered incentives such as cost-share opportunities. In order to remove streams from the 303(d) list, these efforts should be concentrated in the **Council Creek, Dairy Creek, East Fork Dairy Creek, East Fork Dairy – Gumm Creek, Lower McKay Creek, and Middle McKay Creek** subwatersheds, along with subwatersheds along the extent of **West Fork Dairy Creek**.

Agencies and animal-owning partners should intensify efforts to keep sources of animal waste from entering streams. NRCS/SWCD should continue efforts to identify sources of animal waste to aquatic systems and to work with land owners to eliminate these sources. Together, they should implement appropriate measures, potentially including livestock exclusion, vegetation buffers, and proper storage and application of waste. NRCS/SWCD should continue efforts to publicize available cost-share programs to implement these measures. In order to remove streams from the 303(d) list, these efforts should be concentrated in the **Council Creek, Dairy Creek, East Fork Dairy Creek, East Fork Dairy – Gumm Creek, Lower McKay Creek, and Middle McKay Creek** subwatersheds, along with subwatersheds along the extent of **West Fork Dairy Creek**.
Agencies and partners should work together to improve fertilizer management for agricultural, forestry, and urban applications. NRCS/SWCD, other appropriate agencies, and educational institutions should seek funding to continue studies to determine optimal fertilizer application levels. As funding becomes available, they should conduct these studies expeditiously. They should distribute findings of these studies to applicable agency personnel and private agriculture, forestry, and landscaping businesses. Additionally, they should update publicly accessible literature to include the most current findings and create a distribution system to ensure that the literature makes its way to applicable personnel.

NRCS/SWCD should continue to work with land owners to implement Agricultural BMP's that reduce nutrient laden runoff to streams.

Problem: Phosphorus levels in much of the watershed are well above TMDL levels.

Solution Strategy: Due to high natural groundwater levels of phosphorus, massive declines in summertime phosphorus loads are unlikely (except on Waibel Creek). However, continuing efforts will be essential to retaining instream phosphorus at or slightly below current levels. Measures taken to minimize sediment delivery to streams, as well as effective nutrient and animal waste management will limit inputs of adsorbed phosphorus. Reductions in readily decomposable organic matter will reduce anaerobic streambed conditions that release phosphorus from sediments.

Specific Recommendations:

- NRCS/SWCD should continue implementation of rural Best Management Practices and educational programs, especially with respect to nutrient management, animal waste management, livestock grazing, and erosion control.

- An agency or educational institution should conduct a study to determine sources of high phosphorus levels on Waibel Creek.

- Partners and agencies should implement measures to reduce inputs of sediment, manure, grass clippings and other non-woody organic matter to streams.

- Agencies and partners should avoid practices that resuspend stream bottom sediments.

- ODEQ or another agency source should conduct a study to investigate the role of inadequate septic systems in contributing to phosphorus loads. In stream reaches inadequate septic systems are found to be a significant contributor of phosphorus, the source should be identified, and a cost-share program should be implemented to upgrade the septic system to adequate standards.

Problem: Many streams in the Tualatin Plain have temperatures detrimental to salmonids and other aquatic life preferring cool water conditions.

Solution Strategy: Strategies for temperature moderation should focus on protection and restoration of the riparian canopy. Some stream reaches would also receive local reduction of water temperature through leasing of additional instream water rights.

Specific Recommendations:

The Tualatin River Watershed Council, partners, and agencies should work together to implement programs to restore canopy cover through revegetation of the riparian zone with appropriate species. (See under Erosion).

The Tualatin River Watershed Council should explore leasing options for additional instream water rights (See under Hydrology/Water quantity)

Problem: Dissolved oxygen levels are low in some streams within the watershed. Streams with known dissolved oxygen problems include ***Council Creek and the West Fork of Dairy Creek.***

Solution Strategy: Temperature reduction is an important strategy for increasing dissolved oxygen levels. Additionally, strategies should focus on reduction of total chemical oxygen demand.

Specific Recommendations:

- TRWC, partners, and agencies should work together to implement recommendations designed to reduce temperature.

- TRWC, partners, and agencies should work together to limit disposal of organic debris near streams. Agency sources should review current information dissemination methods to determine whether they are adequately informing landowners on proper waste disposal methods and current regulations restricting near-stream waste disposal. They should revise educational methods as necessary.

- NRCS/SWCD should continue to work with animal owners to implement waste management recommendations designed to reduce nutrient inputs to streams (listed earlier).

Problem: Low summer pH levels potentially create a hazard to aquatic life. This problem limits water quality on ***East Fork Dairy Creek.***

Solution Strategy: Low summer pH levels are often due to decomposition of organic material. Strategies should focus on waste management from agricultural and domestic sources, and reduction of algal growth.

Specific Recommendations:

- NRCS/SWCD should work with land and animal owners to implement measures for management of waste and organic debris that have been recommended to address dissolved oxygen and nutrient issues.

Aquatic species and habitat issues

Problem: Salmonid populations are declining. A large proportion of this decline can be attributed to degradation of habitat and water quality.

Solution Strategy: Attempts to restore salmonid populations should focus on habitat preservation and restoration. Tributary preservation is particularly important for cutthroat, while preservation and restoration of mainstem habitats will aid anadromous steelhead trout and coho salmon, as well as the resident cutthroat trout. Habitat preservation should mainly concentrate in the mountains and adjacent narrow valleys, where most existing habitat is located.

Habitat restoration can also provide an important role in the watershed. However, restoration should not substitute for preservation of currently suitable habitats. A likely restoration site is the East Fork Dairy Creek above Greener Road. As late as 1995 this was one of the best salmonid rearing and spawning sites in the Tualatin Basin, which indicates high potential for fish use if habitat is restored. Other restoration efforts should focus on other degraded sites within the Tualatin Mountains, as well as valley sites near to the mountains. If restoration efforts are performed well, these sites have good recolonization potential.

Compared to the mountains, habitat restoration of most streams in the Tualatin Plain has less potential for direct benefit to salmonids. In these reaches, the substrate is generally unsuitable for spawning and salmonid rearing is very limited. However, other native fish and amphibian species could derive benefit from restoration at these sites. Appropriate restoration strategies for valley plain sites should focus on development of appropriate habitat characteristics for these native non-salmonid fish and amphibian species, as well as minimization of obstacles to migration of anadromous fish.

Restoration strategies should focus on restoring channel structure, roughness elements, and habitat diversity. Lack of large woody debris (LWD) seems to be the most important factor impacting channel structure. Current LWD recruitment potential is poor. LWD placement is a viable short-term option, but should not replace riparian protection and other measures that will provide for long-term recruitment potential. Other measures, such as restoration of stream canopy and improvement of water quality, coincide with objectives of other modules. If efforts are taken to address concerns related to erosion, hydrology, water quality, and stream channel characteristics, benefits to fish will accrue.

Specific Recommendations:

- TRWC, partners, and agencies should work together to preserve existing salmonid spawning and rearing habitat. They should conduct surveys to determine the location and condition of such habitat. During these surveys, appropriate restoration sites should be noted. For optimal results, surveys for steelhead trout habitat should be concentrated within the **Upper West Fork Dairy Creek, Burgholzer Creek, Upper East Fork Dairy Creek, East Fork Dairy – Plentywater Creek, Denny Creek, Upper McKay Creek, and McKay – Neil Creek** subwatersheds. Additional habitats for resident cutthroat trout may be found in other tributaries. Murtagh et al. (1992) identified Poliwaski Canyon and Strassel and Lousignont creeks as sites in particular need of stream surveys.

- TRWC, partners, and agencies should work together to restore instream habitats for salmonids. Such restoration may include placement of large woody debris and/or instream channel structures. Restoration projects should be accompanied by monitoring to determine the most effective techniques. A recommended site for restoration is the East Fork Dairy Creek in the lower reaches of the **Upper East Fork Dairy Creek** subwatershed. Additionally, East Fork Dairy Creek between Roy Road and Highway 26 (**East Fork Dairy – Gumm Creek** subwatershed) was identified by USA (1995) as likely reach for restoration. Most other potential restoration sites may be found in degraded reaches within the subwatersheds listed under "preservation".

- TRWC, partners, and agencies should work together to restore riparian vegetation. Partners should plant appropriate native tree species where the natural riparian canopy has been removed. Where non-native shrub and herb species such as Himalayan blackberry and reed canarygrass have invaded riparian habitats, partners should replace these species with appropriate native trees and shrubs. This recommendation applies throughout the watershed. Areas where riparian restoration would provide the greatest potential benefit for fisheries includes the **East Fork of Dairy Creek** between Mountaindale and Murtagh Creek, and **McKay Creek** between its East Fork and Jackson Creek. For other areas with very poor riparian cover, see recommendations in the Erosion section.

- Landowning partners and appropriate agencies should remove obstructions to fish migration. They should replace culverts and other stream crossing structures that do not provide adequate passage. In some cases, road decommissioning[1] and culvert removal may be a desirable option.

- The Tualatin River Watershed Council should provide input to ODFW to formulate an aquatic habitat plan. The Council should also act as facilitator to help resolve differences between competing social and biological interests.

- Conservation organizations, other partners, or agencies should acquire land or conservation easements in crucial riparian habitats. Agencies should promote incentives for private land owners to implement BMP's designed to protect aquatic habitat. The TRWC, partners, and agencies should strive to form cooperative fisheries enhancement projects across ownership boundaries that maximize habitat improvement.

Problem: Emergency measures taken to preserve roads and other public works during flooding events have resulted in destruction of salmonid habitat.

Solution Strategy: Cooperative planning between wildlife agencies and public works agencies is necessary to prevent future occurrences of habitat destruction. This planning should take place prior to the next emergency event, and should incorporate a streamlined process for handling emergencies.

Specific Recommendations:

- Public works agencies, USFWS, ODFW, and other agencies entrusted with protection of wildlife and aquatic resources should prepare a coordinated, cooperative emergency plan. This

[1] FEMAT (1993) defines road decommissioning as removing "those elements of a road that reroute hillslope drainage and present slope stability hazards. Most of the road bed is left in place". This contrasts with "full site restoration", where the complete roadbed is obliterated and the hillslope is restored to its original contours.

plan should include a streamlined notification process to all pertinent agency personnel when emergency measures requiring channel or habitat alteration are considered necessary. Agency personnel should be prepared to respond promptly to such notification and provide input on correct design and implementation of emergency measures. In anticipation of events when prompt response is infeasible, a set of standard guidelines for handling emergency measures requiring channel or habitat alteration.

Problem: Reductions in wetland area have led to depletion of habitat for wetland and riparian species. This has adversely impacted populations of these species, especially amphibians.

Solution Strategy (Wetlands): The most effective policy given current constraints is to protect existing wetland resources, and to prevent encroachment of activities that are incompatible with wetland function. As financing becomes available, procurement of additional lands and conservation easements will also assist in providing wetland habitat. Where incompatible uses do not already exist, there may be opportunity to restore the functionality of degraded wetlands. For example, eradication of reed canarygrass and restoration with native vegetation may enhance the habitat values of these wetlands. Opportunities for wetland enhancement may be available on lands recently acquired by the Jackson Bottom Wetlands Preserve. Additionally, opportunities may exist to enhance habitat values within storage ponds. Many of these ponds already provide open water habitat for waterfowl. Emergent species could be planted along pond margins to increase habitat values for amphibians and other species dependent on shallow water habitat. However, this approach may cause conflicts with other interests using the ponds.

Where feasible, wetland creation could be encouraged by promoting beaver activity. It is anticipated that this approach would work best in the Tualatin Mountains, where fewer conflicts between beavers and management activities exist.

Solution Strategy (Riparian habitats): Strategies for riparian dependent species should emphasize increasing the amount of riparian habitat. Programs are currently underway to meet this objective. One such program is the Conservation Resource Enhancement Program (CREP). Administered by the NRCS, this program provides financial incentives for farmers to establish buffer strips along streams. It is hoped that this and similar programs will increase the amount and quality of habitat available to riparian dependent species.

Specific Recommendations:

- The TRWC should coordinate with partners and agencies to perform population surveys to determine the extent of amphibian species, as well as other riparian and wetland-dependent species.

- The TRWC, partners, and agencies should evaluate and implement programs to restore wetland functionality. These are discussed in the section titled "Hydrology and Water Quantity".

- Conservation organizations, other partners, or agencies should acquire habitat conservation easements in riparian areas.

- The TRWC should facilitate a forum to explore opportunities for beaver production of wetland habitats, as well as means of resolving potential conflicts between beavers and socio-economic interests.

TERRESTRIAL

Vegetation issues

Problem: Management practices have resulted in a change in vegetational characteristics. Amounts of vegetation in late-successional stages has been severely reduced from reference levels. Hardwoods have invaded areas formerly dominated by conifers.

Solution Strategy: The ability to resolve these problems will depend on the management emphases of different landowners. Portions of federal lands are managed under a specific directive to manage for old-growth characteristics. Generally, private lands are not managed under such a directive. Often, restoration of conifers to hardwood areas is in the management interests of both federal and private landowners.

Specific Recommendations:

- Where feasible, landowners should reestablish conifers on sites where hardwoods have invaded.

- Large landowning partners are encouraged to manage currently mature stands of private forests to develop late-successional characteristics.

Noxious/Exotic Plants

Problem: Native species richness within most of the watershed has been compromised by invasive exotic and noxious weeds.

Solution Strategy: Solutions are best achieved by creation of partnerships between the BLM and other land owners. Given the fragmentation of ownerships, the best opportunities for partnerships to reduce the spread of noxious weeds would lie with large landowners, and with organizations representing large amounts of land ownership. Such opportunities could include a cooperative agreement between:

- The Bureau of Land Management;
- Oregon Department of Agriculture, which is contracted by BLM for weed eradication work;
- Industrial owners, of which Longview Fibre is the largest. These measures would probably work best in the East Fork drainage, as the largest blocks of BLM and Longview Fibre lands are located there;
- Washington County, which could assist with roadside weed eradication. However, many owners prefer to retain a no-spray zone beside their properties;
- The Farm Bureau. Cooperation of this entity would be essential in the valley plain. However, with some weed species, farmers may need an economic incentive to pursue eradication.

Small residential landowners may be difficult to enlist toward any organized eradication effort. The best strategy to pursue with such landowners is an educational approach. Prospects for eradication in areas of such ownership are dim.

Success of eradication efforts will vary. Some species, such as Himalayan blackberry, are ubiquitous within the watershed, and we can only hope for localized success in eradicating such species. To prevent recolonization by weed species, planting and cultivation of desirable species should accompany weed eradication.

Specific Recommendations:

- The watershed council should facilitate contact between the BLM, Farm Bureau, ODA, NRCS, SWCD, private industrial landholders, and other entities representing landholders to form partnerships to combat noxious weeds. The Council should coordinate efforts by other groups with current efforts being conducted by the Oregon Department of Agriculture. If feasible, eradication efforts should emphasize non-chemical methods near aquatic systems. Non-chemical methods should also be considered for other areas.
- NRCS, SWCD, and other applicable agencies should advertise the availability of educational pamphlets encouraging eradication of noxious weeds. These pamphlets should be updated as necessary to address problems specific to the Tualatin Valley.
- TRWC, ODA, SWCD, and concerned partners should form a committee to determine which plants have the capability to become noxious weeds within the Tualatin Basin. The committee should work with the appropriate agencies, nurseries, and consumer groups to restrict the ability of these plants to become naturalized within the basin. In particular, scrutiny should be given to giant reed (*Arundo donax*) and Pampas grass (*Cortaderia selloana*).

Species and habitat issues

Problem: Many plant and animal species in the watershed are sensitive to management-induced habitat changes. The Bureau of Land Management has included many of these species on its list of sensitive species. Habitat for many of these species has been reduced from former levels.

Solution Strategy: Proper management strategies for sensitive species will vary by the species. The Bureau of Land Management has identified management strategies for species considered by the Bureau to be sensitive[2].

Knowledge of species distribution is an important prerequisite for successful management for sensitive species. In order to gain this knowledge, systematic surveys should be conducted where habitats are suitable for these species.

Specific Recommendations:

- The watershed council should act as a facilitator to formulate uniform habitat management policies.
- Government policy makers should consider providing incentives for landowners to manage forests for recruitment of snags and down wood.
- The watershed council should seek funding and facilitate partnerships to conduct systematic surveys for sensitive species.

SOCIAL

Issues related to human uses

Problem: Timber, agricultural, domestic, industrial, and wildlife interests often come into conflict for limited resources. As population increases, this competition will intensify.

Solution Strategy: A cooperative approach between various interests is necessary to resolve competing watershed demands. The Tualatin River Watershed Council plays a major role in facilitating this cooperation.

Specific Recommendations:

- In order to achieve Oregon's environmental policy objectives, the Governor's Watershed Enhancement Board should continue funding for the Tualatin River Watershed Council.
- Urban growth should be restricted to the current UGB. Additional extensions of the UGB are detrimental to the watershed. Any new growth should implement technologies that decrease urban runoff and increase infiltration, such as porous pavements and artificial wetlands.

Recreation

Problem: Nearstream recreational activities can lead to disturbance of the riparian zone. Support activities associated with recreational facilities can contribute pollutants to streams.

[2] These are given in BLM Manual 6840, Appendix J2 of the NFP, and in the Salem District RMP.

Solution Strategy: Measures should be taken to minimize the effects of recreational activities upon streams. These include regulation of stream access, maintenance of vegetated buffer strips between streams and activities detrimental to the aquatic system, and monitoring to determine the location, nature, and magnitude of recreation-associated impacts on streams.

Specific Recommendations:

- TRWC, agencies, and partners should work together to conduct a survey to determine specific sites of impacts due to recreational access to streams. Determine whether recreational benefits outweigh impacts at these sites. Where continued access is considered beneficial, consider armoring the streambank or otherwise constructing facilities to minimize impacts.
- Agencies should monitor golf courses and parks to ensure that they do not contribute appreciable inputs of fertilizers, pesticides, and herbicides to stream systems. Managers of these facilities should be encouraged to develop conservation plans through NRCS/SWCD.

Cultural resources

At present, neither problems nor recommendations for cultural resources have been identified.

Road Related Issues

Problem: Roads are significant contributors to problems related to erosion, water quality, stream channels, and aquatic life (see respective sections).

Solution Strategy: A diversified strategy is necessary to deal with road-related problems. This strategy will consist of a combination of road closures, road upgrades, and measures to restrict road-related impacts upon streams.

Specific Recommendations:

- Landowning partners should avoid building new roads on steep terrain (e.g. steep portions of McKay Creek and Williams Creek drainages). Where feasible, roads in these areas should be decommissioned. (See Erosion). Potential criteria for road closure are given on page 32.
- Surveys should be conducted to locate "legacy roads" and abandoned railroad grades that may be posing problems to watershed resources. Additionally, funding should be sought to reduce impacts from these roads.

Recommendations on BLM lands

The following recommendations were specifically designed to fulfill management objectives on BLM lands. Many of these recommendations may be potentially useful on other ownerships, as well.

AQUATIC

Erosion issues

- Where appropriate, reduce existing soil compaction levels by obliterating roads that are not needed for future management and by treating old compacted areas such as dirt roads and cat trails with a winged subsoiler.

- Identify road-related sediment problems, such as old railroad grades with inadequate or failing water crossing structures and roads with failing sidecast. Evaluate the potential for sediment delivery from these sources to determine whether it is appropriate to fix the problems.

Stream channel issues

- Conduct surveys to determine appropriate sites for enhancement projects to increase the amount and size of large woody debris in stream channels, floodplains, and riparian areas. The highest priority areas for enhancement projects are those streamside areas that are dominated by hardwoods or overstocked conifer stands that would benefit from thinning or underplanting.

Water quality issues

- When doing enhancement projects in Riparian Reserves, avoid removal of vegetation along perennial streams that will significantly decrease stream shading during the summer months.

- When conducting forest density management projects inside Riparian Reserves, leave a no-cut vegetation buffer along all intermittent and perennial stream channels, lakes, ponds, and wetlands. The width of this buffer should be determined on a site-specific basis. Additionally, the buffer should include stream-adjacent slopes with a high potential for landsliding. The purpose of this is to protect the streams and riparian zones from any direct or indirect disturbance from project activities, and to ensure that existing shading is not reduced.

- Where a few scattered understory conifers are growing within riparian areas strongly dominated by alder, consider treatments to increase conifer growth, vigor, and exposure to sunlight.

- Consider possible conversion or pocket planting of conifers along stream segments that are dominated by hardwoods.

- Where feasible, avoid road-building activities within Riparian Reserves. Where these activities are necessary, use practices that minimize hazards to aquatic systems.

- When yarding through Riparian Reserves, yard away from or require full log suspension over all stream channels, lakes, ponds, and wetlands. Limit soil disturbance by selecting appropriate yarding systems and restrictions based on site analysis.

Aquatic species and habitat issues

- Maintain active participation in the Tualatin River Watershed Council. Designate a BLM employee to act as liaison with the council. Participate and cooperate in projects when possible and requested to do so by the council.

- Evaluate all stream segments capable, or potentially capable, of supporting salmonid spawning and rearing for potential stream habitat improvement projects. These areas include, but are not limited to East Fork Dairy Creek upstream of Greener Road.

- Explore partnership opportunities with other land owners to evaluate best areas for stream enhancement and to implement enhancement projects.

- Expand efforts to identify fish migration barriers and prioritize barriers for corrective action.

- Take an active role in fisheries information collection and cooperatively distribute information to other land or resource managers. Develop a system to conduct follow-up stream habitat inventories to assess habitat trends over time.

- During the planning stages of timber sales involving Riparian Reserves, consider integrating the use of on site equipment with instream habitat improvement projects.

TERRESTRIAL

Vegetation issues

Noxious/Exotic Plants

- Where appropriate, develop "Memoranda of Understanding" (MOU's) with adjacent landowners and state and county agencies in order to expedite weed control goals.
- Where consistent with safety and management considerations, protect existing native vegetation along roads.
- Consider cleaning heavy equipment that will be used in Riparian Reserves and LSR's, and that will conduct soil disturbing activities, of soil and vegetation from outside sources.
- Consider information from the Oregon State University Weed Survey Report, Spring 1998, to control and prevent exotic/noxious weeds (and invasions of such weeds) on BLM administered lands in the watershed.
- Where feasible, control small weed infestations through manual labor and biological controls.
- Where appropriate to meet management objectives for control of noxious weeds, consider the use of prescribed fire.

Species and habitat issues

- Where appropriate, as opportunities permit, develop MOU's with adjacent landowners (especially industrial owners) to ensure cooperation toward attainment of management objectives for species and habitats.

- Follow enhancement and monitoring guidance in the Conservation Strategy for *Cimicifuga elata*, June 1996.

- Where appropriate to achieve desired wetland characteristics, consider the use of prescribed fire.

- Prepare a Late Successional Reserve Assessment (LSRA) for Big Canyon to determine appropriate management strategies for development of late-successional characteristics within this LSR.

- Maximize the current and future benefits derived from Riparian Reserves, LSRs and administratively withdrawn lands for cavity dwellers and other species dependent upon late-seral stage habitat features. Evaluate LSR stands under 80 years old and Riparian Reserve acres and consider the application of silvicultural prescriptions to benefit the development of late-seral stage habitat. Potentially beneficial treatments include thinning to encourage rapid growth and enhance the development of late seral stage habitat, creating snags (eventual down woody debris), and underplanting with long lived coniferous species in areas where they are largely absent.

- Consider retention of quantities of snags and down wood and wildlife trees in harvest areas commensurate with the availability of such habitat in adjacent areas. Evaluate adjacent sites for current and near-term potential to supply snags and down wood. In young forests and other areas where potential supply is low, retain relatively high levels of snags and down wood and wildlife trees. (As a general guideline, 8-12 wildlife trees may be appropriate). Where sites adjacent to the harvest area have a large proportion of mature timber, less retention of snags, down wood, and wildlife trees will be needed. (For example, 6 wildlife trees may be appropriate).

- Consistent with project objectives, consider the use of logging systems and site preparation methods that would reduce disturbance to reserve trees, existing snags and down wood, especially when operating in Riparian Reserves.

- When implementing silvicultural prescriptions in Riparian Reserves, consider use of logging systems and site preparation methods that would reduce site disturbance, and maintain a "no-cut buffer" appropriate to site specific conditions along stream channels.

- Consider enhancing the recreational hunting experience for some hunters and improve habitat for big game and other wildlife by closing roads where they are no longer needed for management. In particular, this action will be beneficial to late-successional species that are sensitive to disturbance.

- Depending upon site specific conditions, consider providing "visual buffers" adjacent to new regeneration harvest units to limit disturbances to wildlife as well as help with limiting the spread of noxious weeds. Where feasible, maintain an uncut strip of dense native vegetation along roadsides which may include existing young conifers, salmonberry, thimbleberry or other native shrubs.

Forest resources issues [BLM only]

Recommendations for silvicultural treatments in alder-dominated riparian stands[3]:

- Release existing young conifers in riparian areas as the first priority for re-establishing large conifers in alder-dominated riparian areas.

- In Riparian Reserves adjacent to stream channels where conifers are absent or are in very low abundance, consider clearing selected areas in existing alder canopies to plant and maintain young conifers. Openings should probably be 0.5-acre or less and should be well distributed along a given stream reach. Additional areas along the stream reach could be treated when the trees in the first sequence attain sufficient size, perhaps in 10 years or so. Target conifer stocking should be about 50 conifers per acre.

Recommendations for density management thinning in Riparian Reserves:

- Consider thinning well-stocked and over-stocked mid-aged conifer stands in Riparian Reserves to accelerate size development and promote windfirmness in remaining conifers. Variable-density thinnings could also be used to enhance structural complexity of relatively dense conifer stands.

- In young (non-commercial) conifer stands, consider maintaining appropriate conifer stocking adjacent to stream channels or other areas with water to encourage conifer domination of these sites.

- In all management operations, consider maintaining a buffer of trees and brush along stream channels (both intermittent and perennial) sufficient to provide adequate shade to the stream and protect the stream banks and channel.

Recommendations to reduce the potential for excessive damage caused by the Douglas-fir beetle when managing for snags and down wood:

Consider the following:

- Do not leave more than three fresh down Douglas-fir trees per acre greater than 12 inches

[3] These treatments are generally applicable where the natural riparian forest is considered to have been dominated by conifers.

DBH, especially where the down trees are shaded and where tree vigor of the remaining trees is reduced because of root disease or other causes. Where down trees are exposed to full sunlight, the number of trees left for snags and down wood could probably be doubled without posing an undue risk to the surrounding trees.

- When there is a need to add large amounts of fresh down Douglas-fir trees or logs to increase the amount of snags and down wood, add them in a *series* of events spaced three to four years apart.

- To reduce the amount of subsequent killing by Douglas-fir beetles, fell Douglas-fir trees to create snags and down wood no earlier than July and no later than the end of September to avoid beetle breeding and dispersal periods. There may be cases, however, where subsequent beetle killing is desirable for snag creation, such as in Riparian Reserves or LSR's. In these circumstances, adhering to the July to September time period may not always be appropriate.

Recommendations for alder dominated sites:

Consider the following:

- Inventory alder-dominated stands to determine whether to convert particular alder-dominated sites to conifers.

- Those alder-dominated sites capable of supporting conifers at this time, and that are reaching their peak volume production, should be considered for harvesting and conversion to conifer stands to increase timber production in the Matrix. Consider including those alder areas currently suitable for harvest in timber sale plans for the Matrix.

- Alder-dominated sites with compacted soil and/or nitrogen deficiency problems are best left in alder until those problems are alleviated. Sites that are naturally suited to alder production, such as wet areas, are best left in alder and not intensively managed to attain full conifer stocking.

Recommendations for stands infested with *Phellinus weirii* root rot:

Consider the following:

- In regeneration harvests, survey for areas of *P. weirii* infection. Once these areas are located, mark them for subsequent reforestation with disease-resistant or disease-tolerant species.

- Avoid commercially thinning stands of highly susceptible species, such as Douglas-fir, when disease levels are high (present in 20 percent or more of the stand). High levels of *P. weirii* infection are of increased concern when considering commercial thinning, if the disease centers are not well defined.

- Consider early regeneration harvest in pure Douglas-fir stands with disease levels exceeding 25 percent when the disease pattern is dispersed rather than occurring in distinct centers. These stands should be considered relatively high in priority for offering as tracts of timber for sale in the Matrix.

- In disease centers, trees left for wildlife should be species other than Douglas-fir or grand fir if the intent is to have them remain standing.

- In sapling-sized stands of highly susceptible species during pre-commercial thinning, leave disease-resistant or disease-tolerant species in obvious disease centers in a two-tree spacing around the centers.

- In commercial thinning-sized stands of highly susceptible species where infection levels are under 20 percent and infection centers are well-defined (as opposed to dispersed), thin healthy portions of the stand and consider removing all highly susceptible species in the disease centers and within 50 feet of visibly infected trees. In the GFMA, regeneration of the openings created with species that are immune to *P. weirii* should be strongly considered. Red alder is a good choice for an immune species. In the other land-use allocations, regenerate these areas with disease-resistant or disease-tolerant conifer species to increase species diversity, begin the establishment of another canopy layer, and reduce the disease spread.

Recommendations to increase tree growth and value:

Consider the following as funding permits:

- Precommercially thin young conifer stands in all land-use allocations.

- Prune about 100 trees per acre up to 18 feet after precommercial thinning once the average stand DBH reaches four to six inches. Prune the best trees in the stand and do not reduce the crown ratio below 50 percent, which may require pruning to be done in two stages to reach the desired 18-foot height. Pruning is most appropriate in the Matrix land use allocations, especially the GFMA portion of the Matrix.

- Consider fertilization with nitrogen following precommercial and commercial thinning in the Matrix, especially the GFMA portion of the Matrix. Such fertilization should be performed at levels consistent with water quality considerations.

- Promptly reforest regeneration-harvested areas and aggressively manage competing vegetation.

- Where appropriate to achieve management objectives, consider the use of prescribed fire.

- Overstocked Douglas-fir stands that are developing late-seral forest conditions and progress toward achieving late-seral forest conditions should be accelerated by applying density management in the Connectivity portions of the Matrix.

Recommendations regarding relief of compaction using a winged subsoiler:

- Carefully evaluate the trade-off between relieving soil compaction and root damage to residual trees before recommending subsoiling in commercially thinned stands.

General priorities for selecting stands for regeneration harvest in Matrix allocations

1. Pure Douglas-fir stands where more than 25 percent of the area is in *P. weirii* disease centers.
2. Hardwood stands growing on conifer sites where soil compaction is no longer a threat to conifer growth.
3. Mixed hardwood-conifer stands growing on conifer sites where soil compaction is no longer a threat to conifer growth. This priority is particularly applicable to the GFMA portion of the Matrix.
4. Overstocked conifer stands that are no longer suitable for commercial thinning.
5. Conifer stands that have reached or are beyond their peak volume production (culmination of mean annual increment). This priority is particularly applicable to the GFMA portion of the Matrix.

General criteria for selecting stands for commercial thinning in the GFMA

Top priority for commercial thinning should go to Douglas-fir stands that are 30 to 60 years old which have the following characteristics:

- Curtis Relative Density levels in the general range of 55 to 70.

- Live-crown ratios on residual trees of 30 percent or more.

- Less than 20 percent of the stand is in *P. weirii* root rot centers, with the centers being well-defined (as opposed to dispersed).

SOCIAL

Issues related to human uses

Rural interface

To the extent possible:

- Consult community groups and affected landowners during the scoping phase of the environmental assessment process for BLM projects. Increasing our sensitivity to the concerns and desires of the residents of the watershed may decrease conflict on rural interface issues. Participation in watershed councils would provide BLM managers additional information concerning activities occurring or planned within the watershed as well as keeping local publics apprised of BLM activities.

- Reduce vandalism, dumping and resource theft by increasing law enforcement presence through BLM ranger patrols and cooperative agreements with local law enforcement agencies or BLM personnel along with aggressive prosecution of offenders. Public outreach and education programs should also be used to educate the public about the proper use of public lands.

- Where BLM lands lie along publicly accessible roads, post signs on roads indicating boundaries of public lands. At heavily used sites, information signs written to create pride in public ownership, recreational and permit information and asking public assistance in reporting infractions should be erected.

- Produce a pamphlet on BLM management policies in the watershed. Ask realtors to distribute these pamphlets to prospective purchasers of parcels near BLM lands. Make these pamphlets available through other avenues as opportunities arise.

Recreation

- Continue to manage for dispersed recreation opportunities such as hunting, fishing, hiking, and horseback riding. These activities should be allowed to continue on all BLM lands where damage to resource values would be minimal.

- Develop literature for the wise use of the public lands. This literature could provide useful information on what products are available from the public lands and procedures for obtaining a permit. The literature should make the public aware of how their activities impact the resources on forest landscapes and how they could reduce the impacts of their activities.

Road-related issues

Potential strategies to address road-related concerns on BLM land

Road strategy will depend upon BLM objectives within the watershed. To prevent high maintenance costs in the long term, roads should be designed to accommodate the needs of resource management and to accommodate the needs of the resource itself. When constructing new roads, the road network system should be analyzed for future harvest prescriptions, access, and possible obliteration and/or subsoiling of existing roads.

Under certain circumstances, road-related problems may make upgrading or closure desirable. To determine whether these problems warrant closure, the following criteria should be considered:

- Nearness to stream

- Inordinate number of stream crossings

- Large proportion on unstable lands

- High failure history

- Not needed for stand management, fire protection, or other administrative needs.

- High incidence of dumping and vandalism.

- Substantial conflicts with natural hydrologic processes.

Road closure methodology will depend upon the reasons for closure. Such roads as are closed due to dumping or vandalism concerns, but still are potentially useful to BLM operations, should be gated or blocked with debris piles double tank traps. In most other cases, decommissioning would be the preferred option as costs are much lower than for complete obliteration (FEMAT 1993).

The following roads are candidates for closure, obliteration, or subsoiling. These should be reviewed during the final stages of establishment of transportation management objectives (TMO's).

T	R	S	Road number	Description
4N	3W	21	4N-3-21.2 4N-3-21.3	
4N	3W	33	4N-3-33.2 3N-3-3.1	The portion in S33, SE1/4, SE1/4
3N	3W	29	3N-3-29 none	Located in S29, NW1/4, NE1/4
2N	3W	5	2N-3-7 none	Portion in S5, SW1/4, NW1/4 Leaves Road #2N-3-7 in Section 6, SE1/4, SE1/4 and enters S5, SW1/4, SW1/4

The following roads are candidates for easement acquisition:

T	R	S	Road name/no.	Description
3N	2W	9		Needed to access BLM land within S9, N1/2, SE1/4
3N	2W	S18	1050 Layton Road	Both roads are gated.
3N	2W	33	539	
2N	2W	3		Needed to access existing road network
2N	2W	9		Needed to access BLM land in Section 9, NW1/4, S1/2; and SW1/4, N1/2
2N	2W	29		Needed to access BLM land in S29, NE1/4, SW1/4

Consider the need for access to the following parcels. If access is sufficiently beneficial or necessary for management operations, the necessary actions should be taken to provide access.

T	R	S	subsec	Description
3N	3W	29	NE 1/4	No present road access
3N	3W	9	NE 1/4	No present road access
3N	3W	3		Most convenient road access points are closed by landslides.
3N	3W	25	SW1/4	Access closed by landslide
3N	3W	31		Access closed by landslide
3N	3W	35		Access closed by landslide
3N	3W	19		Needs legal access
3N	2W	7		Access closed by landslide
3N	2W	21		Needs legal access
2N	3W	1		Access closed by landslide
2N	3W	11, 12		Needs legal access
2N	3W	21		Needs legal access
2N	2W	7		Access closed by landslide
2N	2W	27		Needs legal access

Culverts

- Culvert spacing should be evaluated. On steep road grades or erodible soils, culvert distance should be more frequent than the standard of every 500 feet. A guideline for placement is:
  - silt and silty sands
    - not more than 150 feet apart on 10% grade,
    - not more than 80 feet apart on 18% grade
  - silt
    - not more than 350 feet apart on 10% grade
    - not more than 150 feet apart on 18% grade
  - rocks, cobbles, gravel
    - not more than 500 feet apart on 10% grade
    - not more than 300 feet apart on 18% grade

- Calculations to determine culvert size should include the volume of water attributed to runoff from insloped roads that flows in the ditch and out of the culvert.

Sediment and Erosion (Preventative Measures)

- Incorporate considerations related to slope, soils, habitat objectives, and hydrologic function into the decision-making process when placing roads near Riparian Reserves.
- Consider obliteration of disused roads with extensive lengths of cut and fill. Obliteration should entail reshaping of the land base to its original characteristics.