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

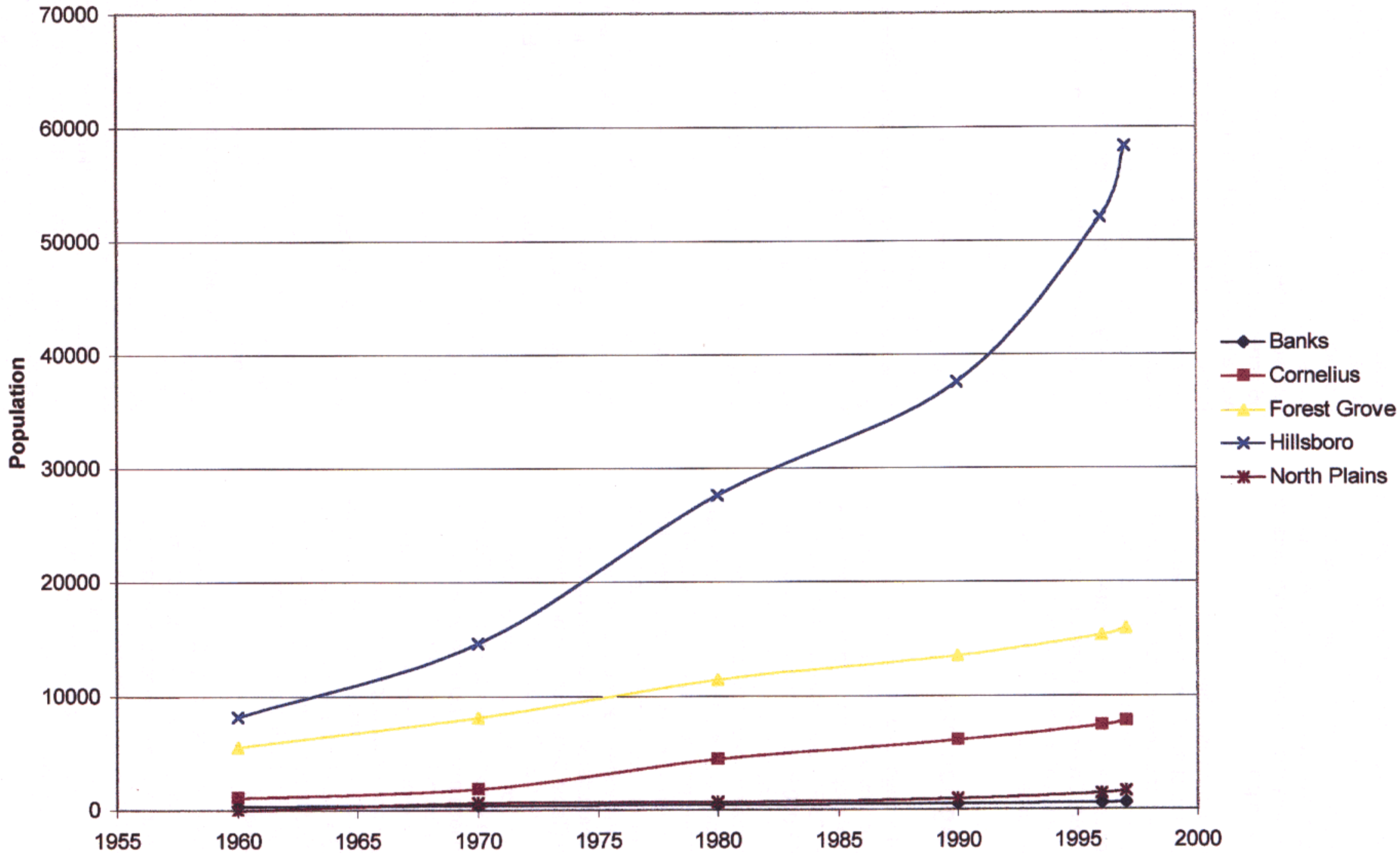
In the Tualatin Mountains, the underlying lithology strongly affects the erodibility of the soils. The weak siltstone formations of the upper reaches of Dairy Creek readily erode into fine-textured particles. Likewise, the ultisols formed from the Columbia River basalt are also quite susceptible to surface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

Stream Name	Above	OCT	NOV 1-15	NOV 16-30	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL 1-15	JUL 16-30	AUG	SEP
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

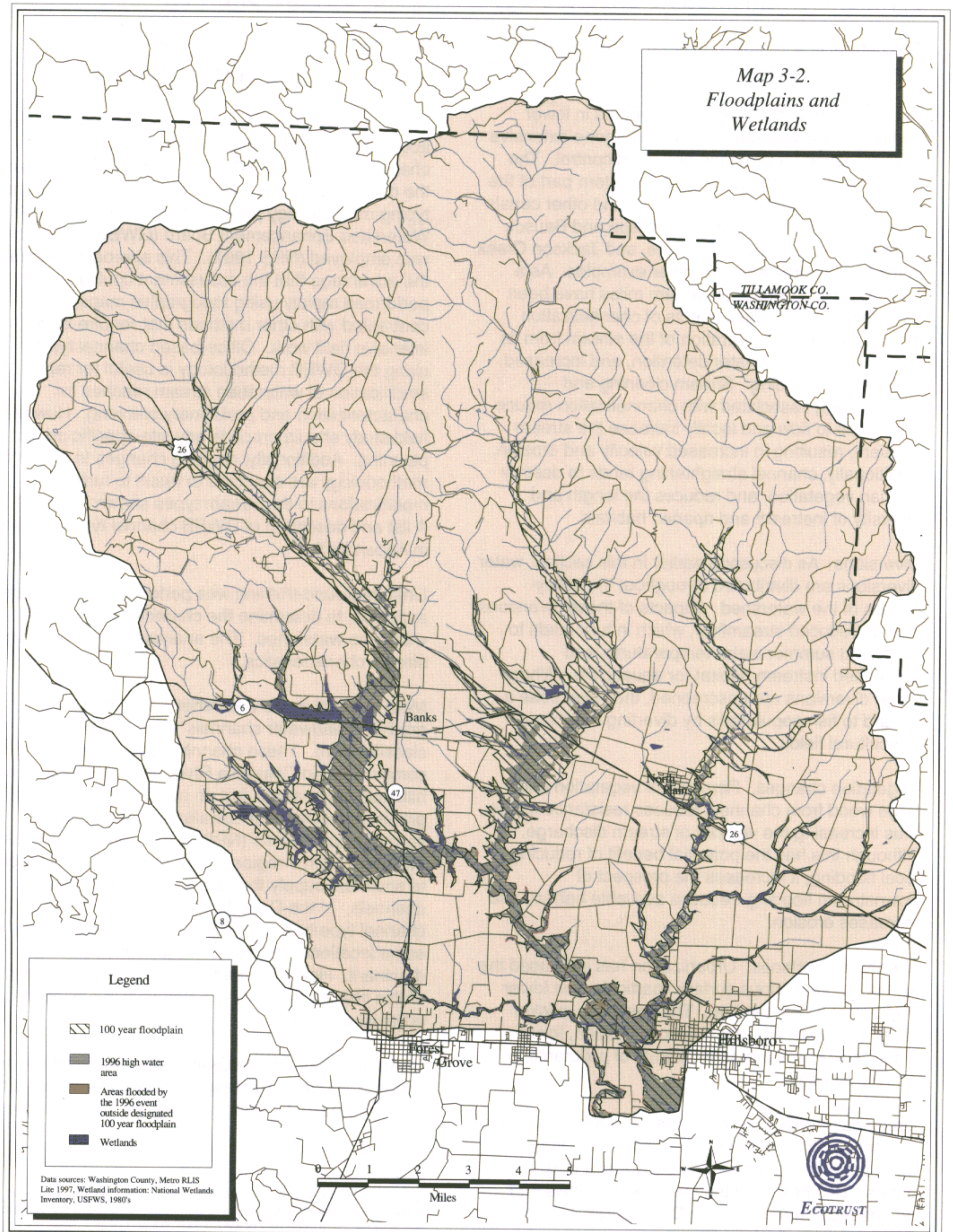
Major stream channels in the watershed were typed according to size, gradient, and confinement characteristics (Map 3-3)[3]. In order to characterize the channel structure within the watershed, a channel typing methodology patterned after the Governor's Watershed Enhancement Board (GWEB) approach was 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

[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 stream, 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.

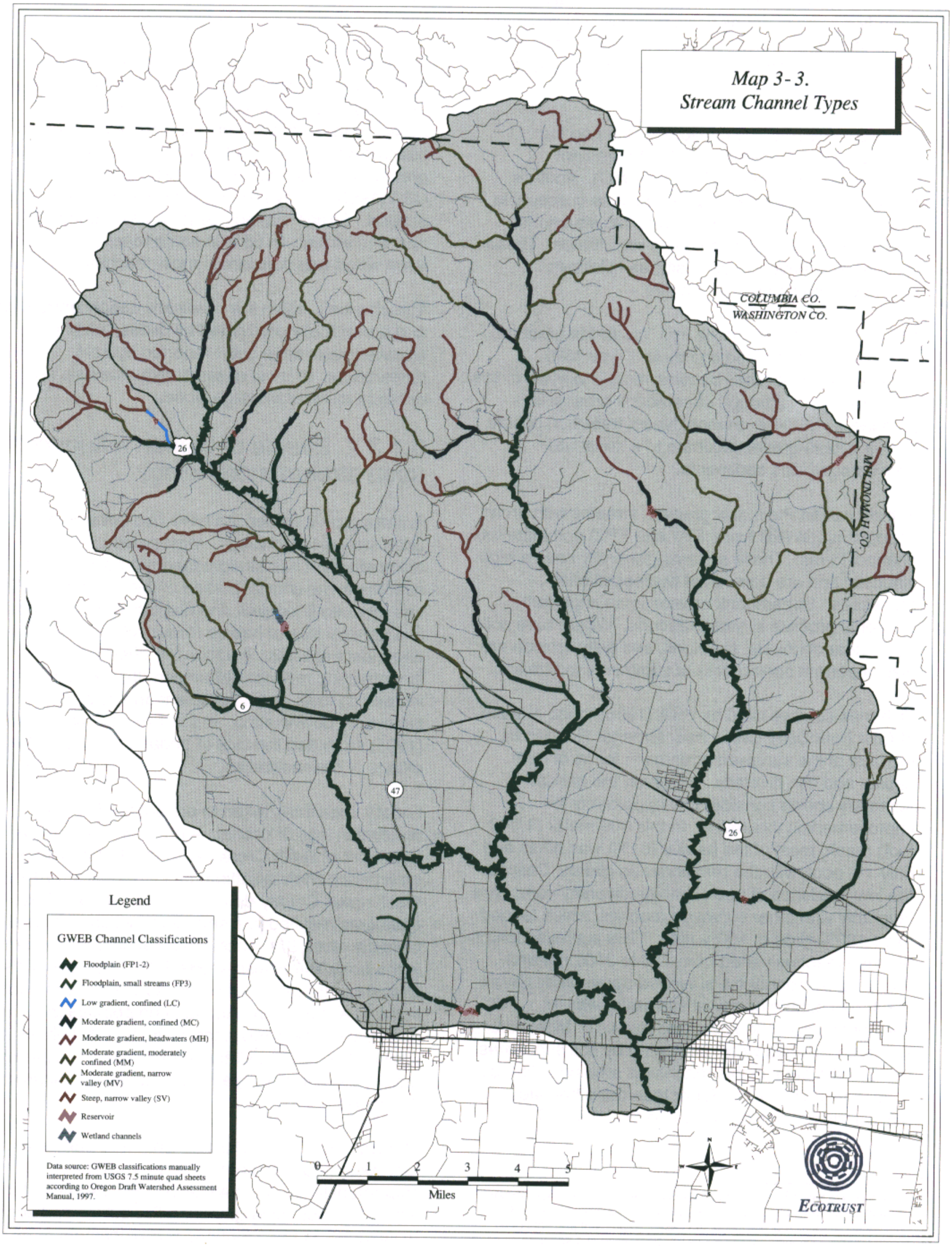
3.1.3.2 Effects of human influences upon stream morphology

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
ECOTRUST

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	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
				Samples per year																	
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

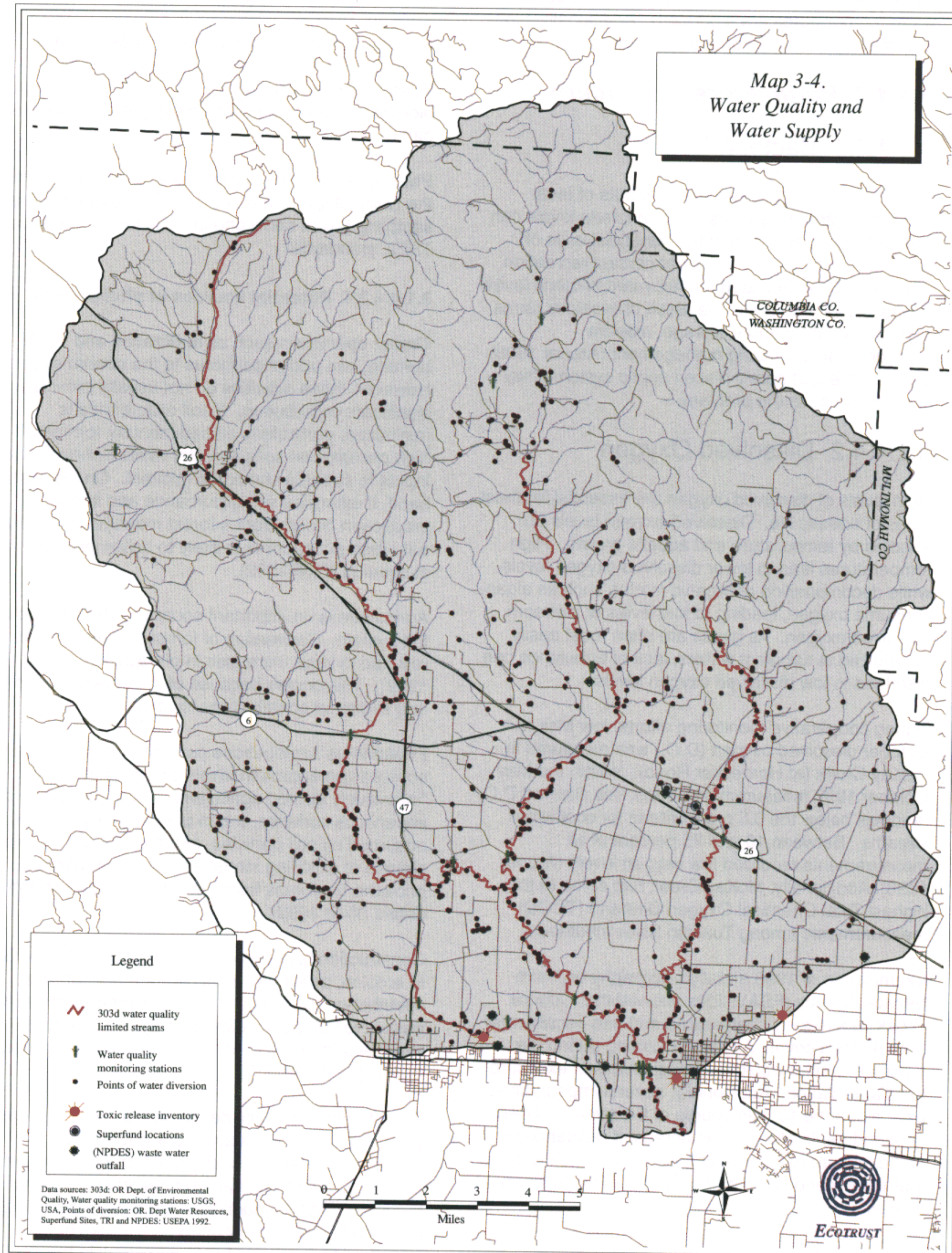
Timber operations such as fertilization and slash burning, can add phosphorus to the stream system. However, these activities do not usually provide a significant contribution. If soil disturbance is minimized, particularly on sedimentary formations and high phosphorus soils, forestry-related phosphorus 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
N
ECOTRUST

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.

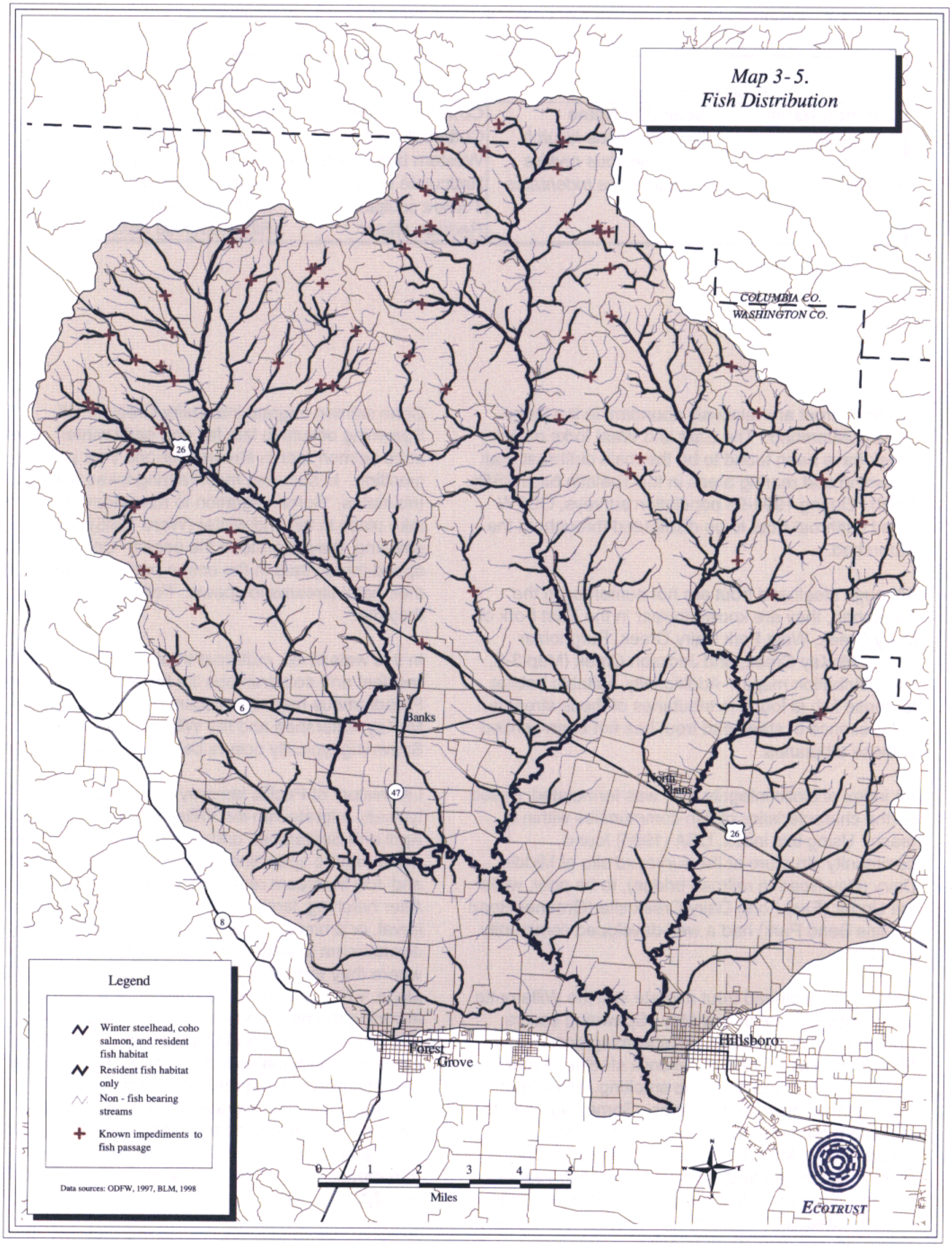
Winter run steelhead trout migrate into the Willamette basin between March and May. Spawning occurs April through June, with peak spawning occurring in May. (Busby et al. 1996). Juvenile steelhead rear in streams for two years prior to smolting. Most trout rearing takes place in tributaries. Some migration 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
47
8
Banks
North Plains
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

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[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

Age Class (years)	Total area (acres)		Percent of allocation	
	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.

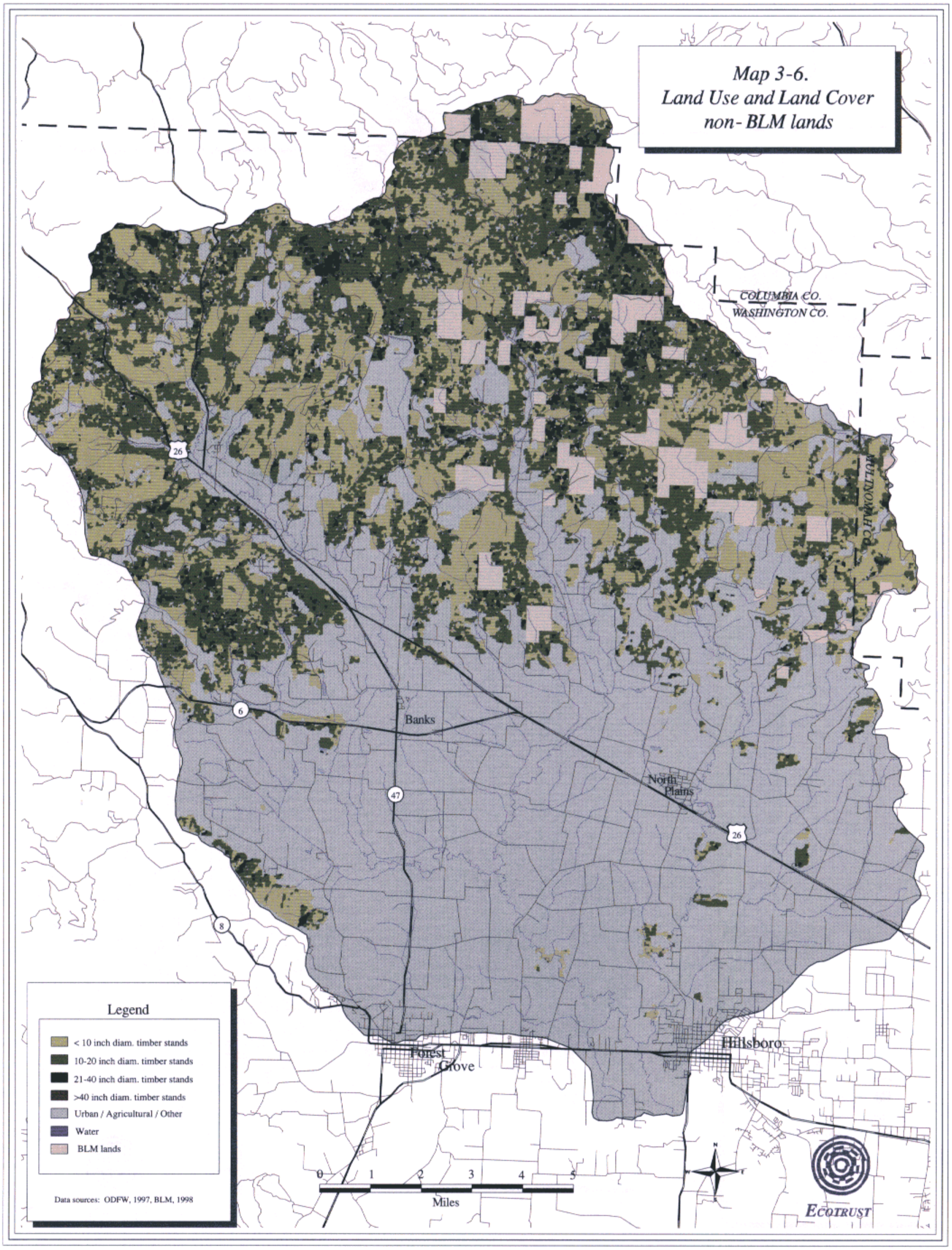
3.2.2 Species and habitat

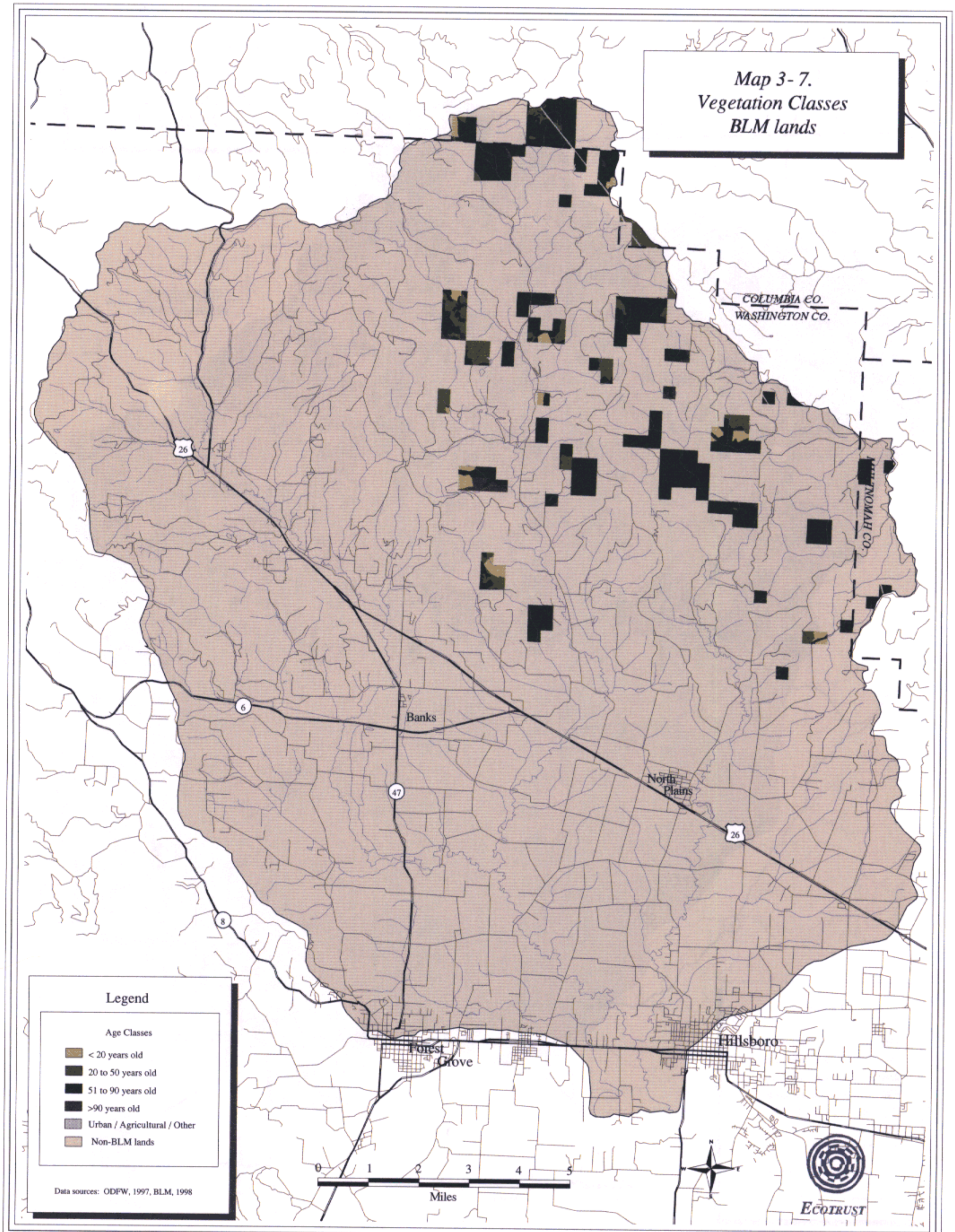
3.2.2.1 Abundance and habitat of terrestrial species

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
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

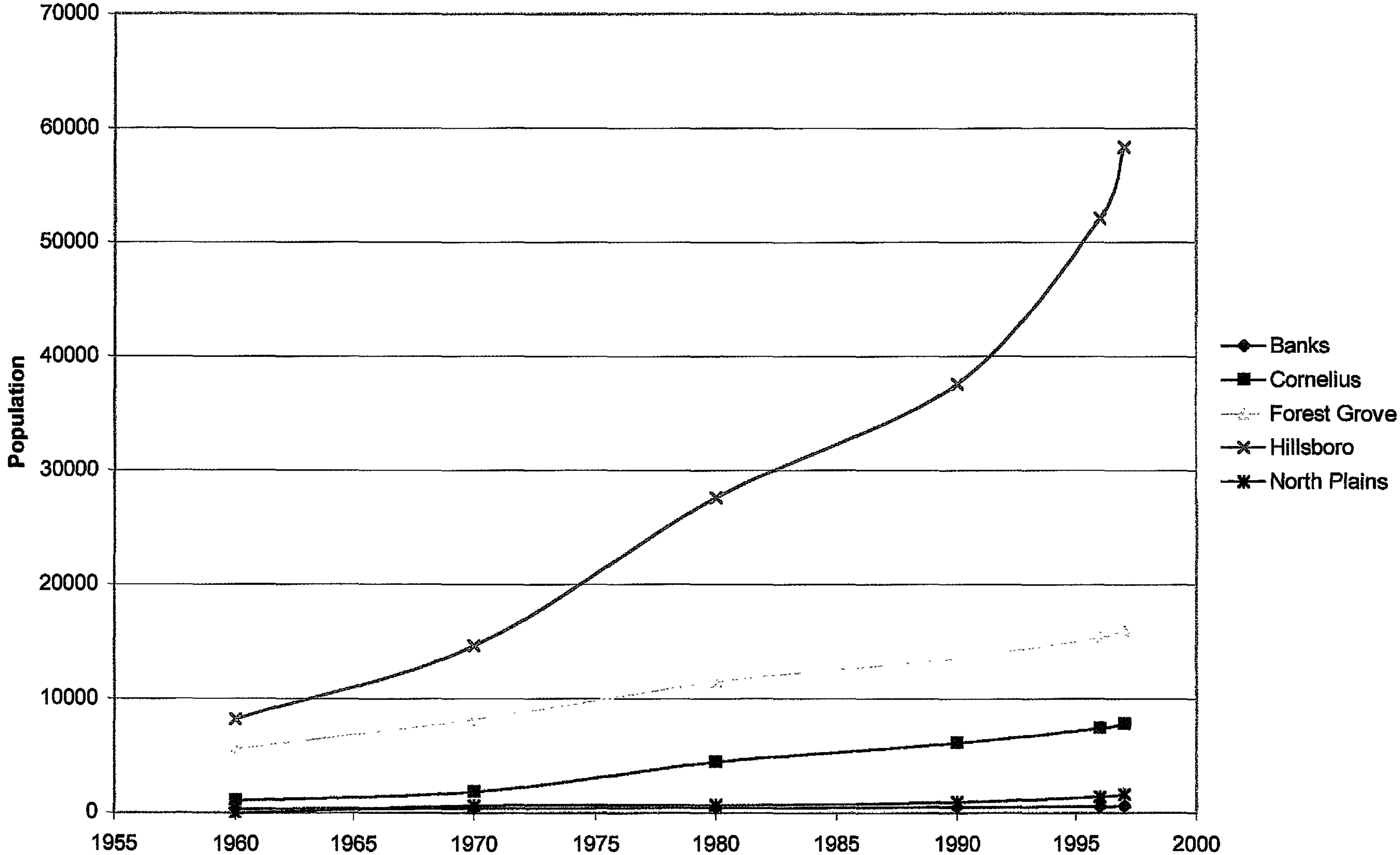
3.3.1.1 Economic Uses

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.

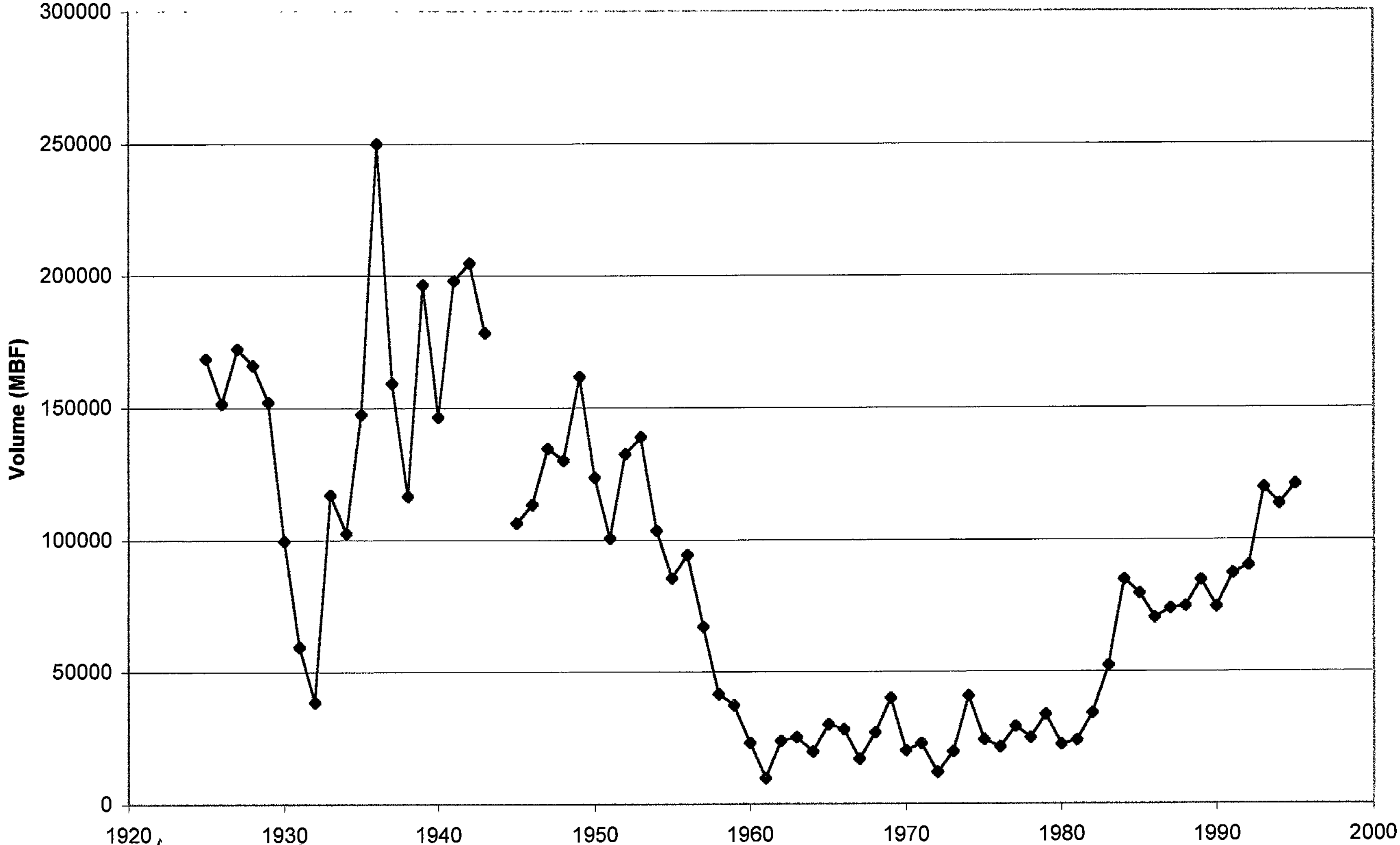
3.3.1.3 Cultural Resources

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.

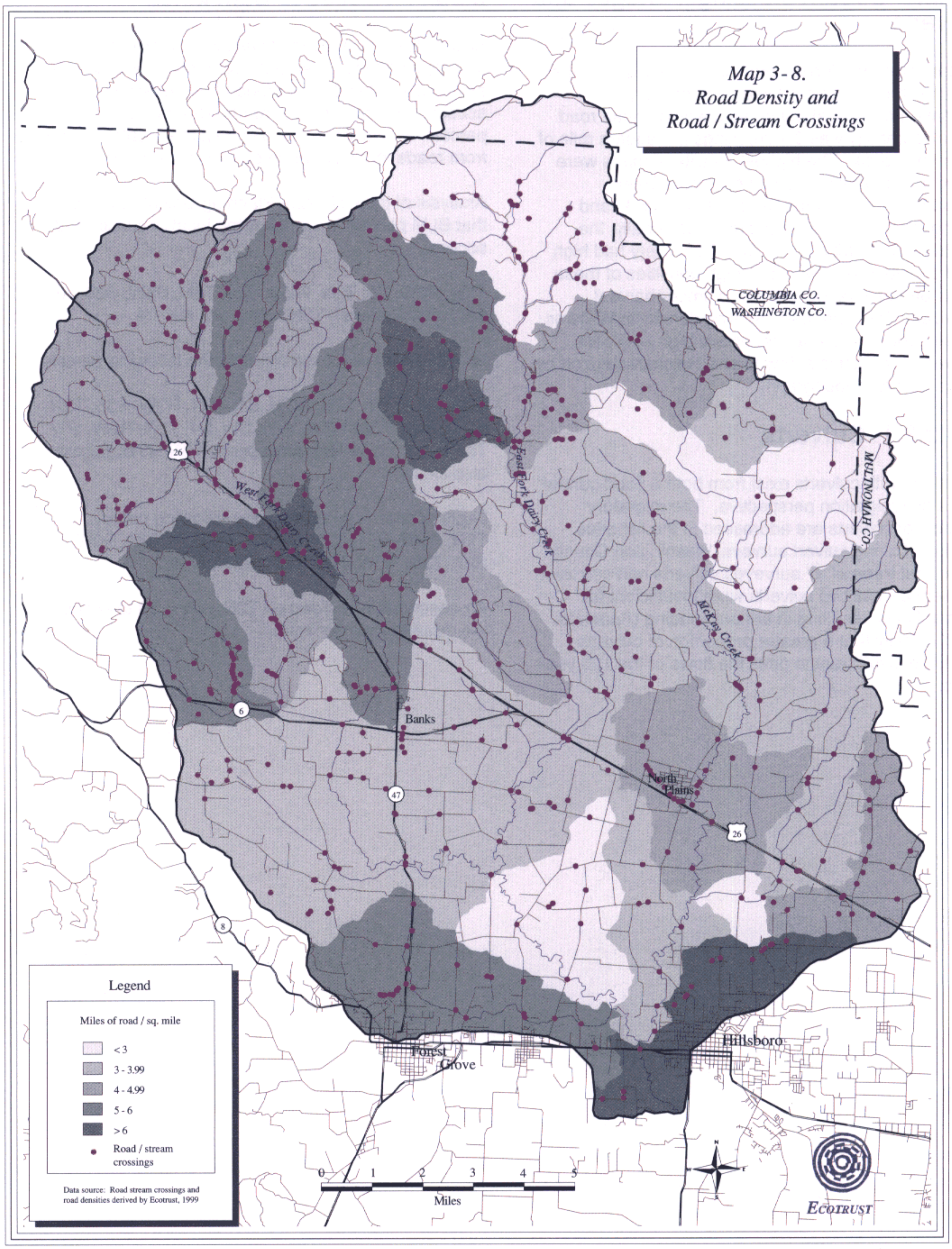
The most extensive areas bearing high-risk characteristics is found in the McKay Creek watershed. Within the McKay - Neil Creek subwatershed, the slopes adjacent to McKay Creek are steep with unstable soils, as are streamside slopes in the East Fork McKay Creek subwatershed. In the latter watershed, 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.
West Fork Dairy Creek
East Fork Dairy Creek
McKay Creek
26
6
47
8
Banks
North Plains
Forest Grove
Hillsboro
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.