CHAPTER FIVE: RIPARIAN & WETLANDS

INTRODUCTION

Riparian zones are the terrestrial areas immediately adjacent to rivers, streams, and wetlands. These areas exhibit soil and vegetative characteristics different from areas farther upland, as they generally have higher soil moisture levels that support more diverse and productive plant communities. Riparian areas provide a number of important functions in the maintenance of aquatic ecosystems. Riparian vegetation stabilizes streambanks and dissipates stream water velocities during higher flows, thereby preventing bank erosion. Riparian vegetation also provides stream shading, reducing the amount of solar radiation reaching the stream and, therefore, preventing accelerated warming of stream water. Fish populations benefit from both instream and overhead cover provided by live and dead riparian vegetation. Inputs of leaves, twigs, needles, and other vegetation from the riparian zone often provide the primary food source for stream insects that, in turn, serve as the food base for trout, amphibians, and other aquatic predators. Additionally, riparian vegetation provides a buffer between the stream ecosystem and upland land uses (Hunter 1991, Franklin 1992) and is believed to be important in controlling the amount of sediment and nutrients entering the stream channel from upstream sources.

Riparian areas are the primary sources of large woody debris (LWD), which also serves a number of important roles in streams and rivers. Large woody debris such as dead trees, root wads, and larger limbs, help shape stream channels by directing the flow of water and capturing sediments, gravels, and debris to increase channel habitat complexity through the formation of pools. More complex habitats and higher pool frequencies created by large woody debris benefit fish populations by increasing habitat quality. LWD slows high water velocities, allowing sediments and organic matter to drop out of the water column, thereby helping to retain these materials in the local stream system for longer periods of time, effectively increasing stream productivity.

Adequate LWD loads in streams are maintained only if suitable numbers of larger trees occur close enough to the stream to enter the water when they fall due to age, disease, or storms. The area from which the stream draws new LWD is called the riparian recruitment zone. A well-stocked riparian recruitment zone will ensure a steady supply of large woody material and a productive and well-functioning riparian area.

Wetlands and protected by federal, state, and local regulations. Knowing the location of wetlands is essential to proper planning of growth and development. Wetlands provide critical watershed functions, including water storage, flood abatement, water purification, and wildlife habitat. In this chapter, we summarize locations and approximate sizes of wetlands known to occur in the watershed.

METHODS

Digital ortho photogpraphs taken in 2000 were used to assess riparian conditions in the Lower Molalla River & Milk Creek watershed. Stream layers from the BLM were overlain on the photos in ArcView to assist with delineating stream channels and buffering left and right banks. The mapping unit used in this assessment of riparian areas is the Riparian Condition Unit (RCU), defined as a segment of the riparian zone of uniform vegetation type, size, and density. RCU lengths vary with the length of contiguous habitat conditions but are generally more than approximately 1000 feet in length. RCUs were further subdivided by stream size, channel habitat type (CHT), subwatershed, and ecoregion. Each RCU was assigned an individual number and then classified or evaluated according to each of the following fields:

> ***Stream Name*** – Streams were named according to the streams layer from BLM. When unnamed tributaries were classified, they were named using numbers assigned in sequential order (e.g., UnTrib1 Cedar Ck, UnTrib2 Cedar Ck).
>
> ***Subwatershed*** – Streams were placed in subwatersheds based upon drainage patterns and 6th field watersheds based on the Regional Ecosystem Offices (www.reo.gov) data.

Ecoregion – Ecoregion boundaries were determined from the ecoregion dataset from SSCGIS. Ecoregion descriptions of the basin were obtained from the OWEB Watershed Assessment Manual (WPN 1999: Appendix A), and are listed in Table 5.1.

CHT – The layer of digitized Channel Habitat Types was overlain on the riparian layer and the CHT of the riparian condition unit assigned. When several CHTs occurred in an RCU, the RCU was divided into two or more RCUs.

Stream Size – Derived from ODF stream survey hard-copy maps, or where lacking, estimated by drainage area and subsequently ground-truthed.

Riparian Area (RA1) Width – The width of vegetation occurring immediately adjacent to the stream (the riparian zone) that most influences water temperature, habitat value, streambank stability, and hydrodynamics of the stream. This width varied from 25 to 100 feet, with channel confinement class and ecoregion (Table 5.1).

Riparian Area 1 (RA1) Code – Riparian areas within each RCU were classified according to vegetation type, size, and density using 3-letter codes (Table 5.2)

RA2 Width – RA2 refers to the area beyond the immediate riparian zone that still occurs within the wood recruitment zone. The RA2 width also varies with ecoregion and channel confinement (Table 5.1).

RA2 Code – This portion of the recruitment zone was classified according to vegetation type, size, and density using the letter coding system used to classify RA1 vegetation (Table 5.1).

Permanent Discontinuities – When a road, bridge, or other man-made structure impinges upon the stream channel, it can prevent full hydraulic expression of the stream by restricting normal stream movements and limiting riparian recruitment. Unlike most other restoration opportunities, areas with permanent discontinuities will have no opportunity to contribute to stream health until the discontinuity is removed.

Shade – Shade was visually estimated as high (70%), medium (40–70%), or low (40%) on each streambank. Banks were often difficult to distinguish on smaller streams, necessitating that each bank receive the same shade code.

Riparian Recruitment – The **riparian recruitment potential** was first classified as adequate or inadequate by comparing RCU conditions to potential riparian zone vegetative characteristics for that ecoregion and CHT. All RCUs classified as inadequate were then further classified according to their **riparian recruitment situation**, which characterizes the immediate land use conditions that are precluding proper adequate riparian zone recruitment. In non-forested ecoregions (i.e. Willamette River Gallery Forest (3b) and Prairie Terraces (3c)), the riparian zones would not have naturally supported enough large trees to establish a significant large woody debris source pool. Therefore, reaches occurring in these areas were classified as having adequate riparian recruitment potential if the riparian zone condition was similar to that naturally occurring in the ecoregion. Otherwise, they were classified as being limited by the dominant land use adjacent to them. The following riparian zone recruitment situations were used to classify RCUs.

--*Adequate* (ADQ): For a given ecoregion, the reach of stream is considered normal, and riparian recruitment is considered adequate to keep large woody debris in sufficient supply in the stream.

--*Agriculture* (AG): Predominately small grain, haying, or nursery activities within

Table 5.1. Ecoregion conditions of the Lower Molalla River / Milk Creek Watershed, Oregon (source: WPN 1999: Appendix A).

Potential streamside vegetation: Willamette River and Tributaries Gallery Forest (3b)

CHT Group	RA1 Zone	RA1 Description	RA2 Width	RA2 Description	Other Considerations
Constrained	100'	**Type:** Hardwoods (black cottonwood, Oregon ash, bigleaf maple, western hawthorn) and shrubs (willows, red osier dogwood, hazelnut, snowberry) **Size:** Large **Density:** Dense	N/A	**Type:** N/A **Size:** N/A **Density:** N/A	Reed canarygrass and Himilayan blackberry (invasive species) often dominate areas without trees. Oregon white oak, Douglas fir, and grand fir grow on adjacent terraces.
Semi-constrained	100'	**Type:** Hardwoods (black cottonwood, Oregon ash, bigleaf maple, western hawthorn) and shrubs (willows, red osier dogwood, hazelnut, snowberry) **Size:** Large **Density:** Dense	N/A	**Type**: N/A **Size:** N/A **Density:** N/A	Reed canarygrass and Himilayan blackberry (invasive species) often dominate areas without trees. Oregon white oak, Douglas fir, and grand fir grow on adjacent terraces above the floodplain.

Table 5.1. Continued.

Potential streamside vegetation: Willamette River and Tributaries Gallery Forest (3b), continued

CHT Group	RA1 Zone	RA1 Description	RA2 Width	RA2 Description	Other Considerations
Unconstrained	100'	**Type:** Hardwoods (black cottonwood, Oregon ash, bigleaf maple, western hawthorn) and shrubs (willows, red osier dogwood, hazelnut, snowberry)	N/A	**Type:** N/A	Reed canarygrass and Himilayan blackberry (invasive species) often dominate areas without trees. Willows dominating the shore are rigid willow, whiplash willow, soft-leaved willow, and Cascade range willow. Oregon white oak, Douglas fir, and grand fir grow on adjacent terraces above the floodplain. Channel often braided and bare gravel deposits and common following winter high flows.
		Size: Large		**Size:** N/A	
		Density: Dense		**Density:** N/A	

Table 5.1. Continued.

Potential streamside vegetation: Prairie Terraces (3c)

CHT Group	RA1 Zone	RA1 Description	RA2 Width	RA2 Description	Other Considerations
Constrained	100'	**Type:** Hardwoods (black cottonwood, willows, Oregon ash, bigleaf maple, western hawthorn) and shrubs (Douglas spirea and snowberry) **Size:** Large **Density:** Dense	N/A	**Type:** N/A **Size:** N/A **Density:** N/A	Reed canarygrass and Himilayan blackberry (invasive species) often dominate areas without trees. Oregon white oak, Douglas fir, and grand fir grow on adjacent terraces that are well drained.
Semi-constrained	100'	**Type:** Hardwoods (black cottonwood, willows, Oregon ash, bigleaf maple, western hawthorn) and shrubs (Douglas spirea and snowberry) **Size:** Large **Density:** Dense	N/A	**Type**: N/A **Size:** N/A **Density:** N/A	Reed canarygrass and Himilayan blackberry (invasive species) often dominate areas without trees. Oregon white oak, Douglas fir, and grand fir grow on adjacent terraces that are well drained.
Unconstrained	100'	**Type:** Hardwoods (black cottonwood, willows, Oregon ash, bigleaf maple, western hawthorn) and shrubs (Douglas spirea and snowberry) **Size:** Large **Density:** Dense	N/A	**Type:** N/A **Size:** N/A **Density:** N/A	Reed canarygrass and Himilayan blackberry (invasive species) often dominate areas without trees. Oregon white oak, Douglas fir, and grand fir grow on adjacent terraces that are well drained.

Table 5.1. Continued.

Potential streamside vegetation: Valley Foothills (3d)

CHT Group	RA1 Zone	RA1 Description	RA2 Width	RA2 Description	Other Considerations
Constrained	0-25'	**Type:** Mixed (Douglas fir, western hemlock, red alder, bigleaf maple) and shrubs (willow, snowberry, Douglas spirea) **Size:** Medium **Density:** Dense	25-100'	**Type:** Mixed (Douglas fir, grand fir, and bigleaf maple) **Size:** Large **Density:** Dense	Few conifers where slopes are unstable or perpetually wet.
Semi-constrained	0-50'	Mixed (Douglas fir, western hemlock, red alder, bigleaf maple) and shrubs (willow, snowberry, Douglas spirea) **Size:** Medium **Density:** Dense	50-100'	**Type:** Mixed (Douglas fir, grand fir, and bigleaf maple) **Size:** Large **Density:** Dense	Few conifers where slopes are unstable or perpetually wet. Vegetation is often highly altered where there is significant beaver browsing and dam building.
Unconstrained	0-75'	Mixed (Douglas fir, western hemlock, red alder, bigleaf maple) and shrubs (willow, snowberry, Douglas spirea) **Size:** Medium **Density:** Dense	75-100'	**Type:** Mixed (Douglas fir, grand fir, and bigleaf maple) **Size:** Large **Density:** Dense	Few conifers where slopes are unstable or perpetually wet. Vegetation is often highly altered where there is significant beaver browsing and dam building.

Table 5.1. Continued.

Potential streamside vegetation: Western Cascades Lowlands and Valleys (4a)

CHT Group	RA1 Zone	RA1 Description	RA2 Width	RA2 Description	Other Considerations
Constrained	0-25'	**Type:** Hardwoods (red alder, cottonwood, bigleaf maple) and shrubs (vinemaple, red osier dogwood, devil's club, stinkcurrant, and salmonberry). **Size:** Medium **Density:** Dense	25-100'	**Type:** Conifers (Douglas fir, western hemlock, western redcedar, true firs at higher elevations). Some hardwoods may be present. **Size:** Large **Density:** Dense	Under a few circumstances, there are a few potential plant communities that have no woody vegetation. These are characterized by herbaceous plants such as Oregon and great oxalis, Cooley's hedgenettle, and lady fern. See Diaz and Mellen (1996) and Campbell and Franklin (1979) for more details about specific plant communities.
Semi-constrained	0-50'	**Type:** Hardwoods (red alder, cottonwood, bigleaf maple) and shrubs (vinemaple, red osier dogwood, devil's club, stinkcurrant, and salmonberry). **Size:** Medium **Density:** Dense	50-100'	**Type:** Conifers (Douglas fir, western hemlock, western redcedar, true firs at higher elevations). Some hardwoods may be present. **Size:** Large **Density:** Dense	Under a few circumstances, there are a few potential plant communities that have no woody vegetation. These are characterized by herbaceous plants such as Oregon and great oxalis, Cooley's hedgenettle, lady fern, skunk cabbage, and lenticular sedge. See Diaz and Mellen (1996) and Campbell and Franklin (1979) for more details about specific plant communities.

Table 5.1. Continued.

Potential streamside vegetation: Western Cascades Lowlands and Valleys (4a), continued

CHT Group	RA1 Zone	RA1 Description	RA2 Width	RA2 Description	Other Considerations
Unconstrained	0-75'	**Type:** Hardwoods (red alder, cottonwood, bigleaf maple) and shrubs (vinemaple, red osier dogwood, devil's club, stinkcurrant, and salmonberry). **Size**: Medium **Density**: Dense	75-100'	**Type:** Conifers (Douglas fir, western hemlock, western redcedar, true firs at higher elevations). Some hardwoods may be present. **Size**: Large **Density**: Dense	Under a few circumstances, there are a few potential plant communities that have no woody vegetation. These are characterized by herbaceous plants such as Oregon and great oxalis, Cooley's hedgenettle, lady fern, skunk cabbage, lenticular sedge, and yellow monkeyflower. See Diaz and Mellen (1996) and Campbell and Franklin (1979) for more details about specific plant communities.

Table 5.1. Continued.

Potential streamside vegetation: Western Cascades Montane Highlands (4b)

CHT Group	RA1 Zone	RA1 Description	RA2 Width	RA2 Description	Other Considerations
Constrained	0-25'	**Type:** Shrubs such as devil's club, stinkcurrant, and salmonberry.	25-100'	**Type:** Conifer (Douglas fir, western hemlock, western redcedar, and true firs)	Under certain circumstances, there are a few potential plant communities that have no woody vegetation. These are characterized by herbaceous plants such as Oregon and great oxalis, brook saxifrage, and arrowleaf groundsel, Cooley's hedgenettle, and lady fern. See Diaz and Mellen (1996) for more details about specific plant communities.
		Size: N/A		**Size:** Large	
		Density: N/A		**Density:** Dense	
Semi-constrained	0-50'	**Type:** Mixed (western redcedar, red alder) and shrubs (mountain alder, ovalleaf and Alaska huckleberry, red osier dogwood, devil's club, stinkcurrant and salmonberry).	N/A	**Type:** Conifer (Douglas fir, western hemlock, western redcedar, and true firs)	Under certain circumstances, there are a few potential plant communities that have no woody vegetation. These are characterized by herbaceous plants such as Oregon and great oxalis, brook saxifrage, and arrowleaf groundsel, Cooley's hedgenettle, lady fern, skunk cabbage, and lenticular sedge. See Diaz and Mellen (1996) for more details about specific plant communities.
		Size: Medium		**Size:** Large	
		Density: Dense		**Density:** Dense	

Table 5.1. Continued.

Potential streamside vegetation: Western Cascades Montane Highlands (4b), continued					
Unconstrained	0-75'	**Type:** Mixed (western redcedar, red alder) and shrubs (mountain alder, ovalleaf and Alaska huckleberry, red osier dogwood, devil's club, stinkcurrant and salmonberry). **Size:** Medium **Density:** Dense	N/A	**Type:** Conifer (Douglas fir, western hemlock, western redcedar, and true firs) **Size:** Large **Density:** Dense	Under certain circumstances, there are a few potential plant communities that have no woody vegetation. These are characterized by herbaceous plants such as Cooley's hedgenettle, lady fern, skunk cabbage, and lenticular sedge. See Diaz and Mellen (1996) for more details about specific plant communities.

Table adapted from WPN 1999 – ecoregion appendix.

Table 5.2. Codes assigned to Riparian Condition Units (RCUs) to characterize riparian vegetation types in the lower Molalla River and Milk Creek watershed, Oregon (WPN 1999).

Code	**Vegetation Type**
C	Mostly conifer trees (>70% of area)
H	Mostly hardwood trees (>70% of area)
M	Mixed conifer/hardwoods
B	Brush species
G	Grass/Meadow
N	No riparian vegetation
Code	**Tree Size Classes**
R	Regeneration (<4 inch average DBH)
S	Small (4- to 12-inch average DBH)
M	Medium (>12- to 24-inch average DBH)
L	Large (>24-inch average DBH)
N	Nonforest (applies to vegetation Types B, G, and N)
Code	**Stand Density**
D	Dense (<1/3 ground exposed)
S	Sparse (>1/3 ground exposed)
N	Non-forest (applies to vegetation Types B, G, and N)

the riparian zone. Active or incidental loss of riparian and hydrologic structure and function has resulted.

--*Infrastructure* (INF): Roads, bridges, housing, and quarries built close to the riparian zone have impaired riparian and/or hydrologic function. These conditions are relatively permanent, and will limit improvement of conditions until a conscious effort is made to remove them.

--*Small Stand Size* (SS): Forestry or fire has resulted in smaller diameter trees than is normal for the ecoregion, thereby limiting recruitment potential.

--*Wetland* (WET): Hydric soils are preventing riparian establishment. Note that no RCU was primarily limited by wetland conditions; however, it occasionally was a secondary limiting factor.

Additional information included adding a secondary riparian recruitment code. Data were field checked in October 2003 by ground-truthing a subset of RCUs.

Finally, data describing riparian vegetation conditions, riparian recruitment situation, and stream shading were summarized by subwatershed to help identify areas most in need of riparian zone improvement and restoration.

Properly functioning wetlands are vital to a healthy stream ecosystem. Flood control, water purification, dry season flow enhancement, salmonid rearing habitat, and terrestrial wildlife enhancement are all tangible benefits of healthy wetland communities. Wetland data from BLM were summarized across the watershed and by subwatershed in order to assess wetland resources within the basin.

RESULTS

A total of 647 Riparian Condition Units were assessed, totaling 516 bank-miles. Because every mile of stream includes two miles of RCUs, RCUs along 258 miles of stream were assessed (Table 5.3). The number of RCUs occurring in each watershed varied with the number of stream miles in the watershed and the heterogeneity of streamside habitat. Subwatersheds with long, uniform stretches of riparian zone conditions had fewer RCUs than did more diverse and fragmented subwatersheds.

RIPARIAN VEGETATION CONDITIONS

Riparian conditions varied widely throughout the watershed. Riparian zones occurring in lower elevation, nonforested ecoregions in the watershed (represented by the Willamette River & Tributaries Gallery Forest (3b) and Prairie Terraces (3c)) were represented by a number of vegetation communities in the RA1 zone. Small, sparse hardwood forest was the most common single riparian condition class, occurring along 21.5 of 87.5 stream bank miles (Table 5.4, Figure 5.1). Brush and grass vegetation classes, combined, occurred along 19.2 of 87.5 stream bank miles. Historically, riparian zones within these

Table 5.3. Number and length (feet) of Riparian Condition Units (RCU) classified by subwatershed in the lower Molalla River & Milk Creek watershed, Oregon.

	Riparian Condition Units		
Subwatershed	**Number**	**Length (ft)**	**Total Stream Miles**
Canyon Creek		303438	28.7
Headwaters-Milk Ck		286138	27.1
Lower Milk Creek		429458	40.7
Middle Milk Ck		276511	26.2
Molalla R/Cedar Ck		395140	37.4
Molalla R/Willamette		417283	39.5
Upper Milk Ck		350702	33.2
Woodcock Ck		265640	25.2
Total		2,724,310	**258.0**

Table 5.4. Number of miles of riparian zone vegetation condition classes by subwatershed in the 3b and 3c (i.e., non-forested) ecoregions of the lower Molalla River and Milk Creek watershed, Oregon. The heading in bold, large/dense hardwood forest, is the predominant natural riparian zone condition in these two ecoregions.

	Non-forested		**Hardwood Forest**					**Mixed-species Forest**				
Subwatershed	Brush	Grasses	**Large/Dense**	Medium/Dense	Medium/Small	Small/Dense	Small/Sparse	Medium/Dense	Medium/Small	Small/Dense	Small/Sparse	Total
Molalla R/Cedar Cr	2.3	1.6	2.5						1.0			7.4
Molalla/Willamette	6.2	8.9	9.4	9.5	3.7	6.6	21.5	3.3		0.7		69.8
Woodcock								3.1		4.3	2.8	10.2
TOTAL	8.6	10.5	11.9	9.5	3.7	6.6	21.5	6.5	1.0	5.0	2.8	87.5

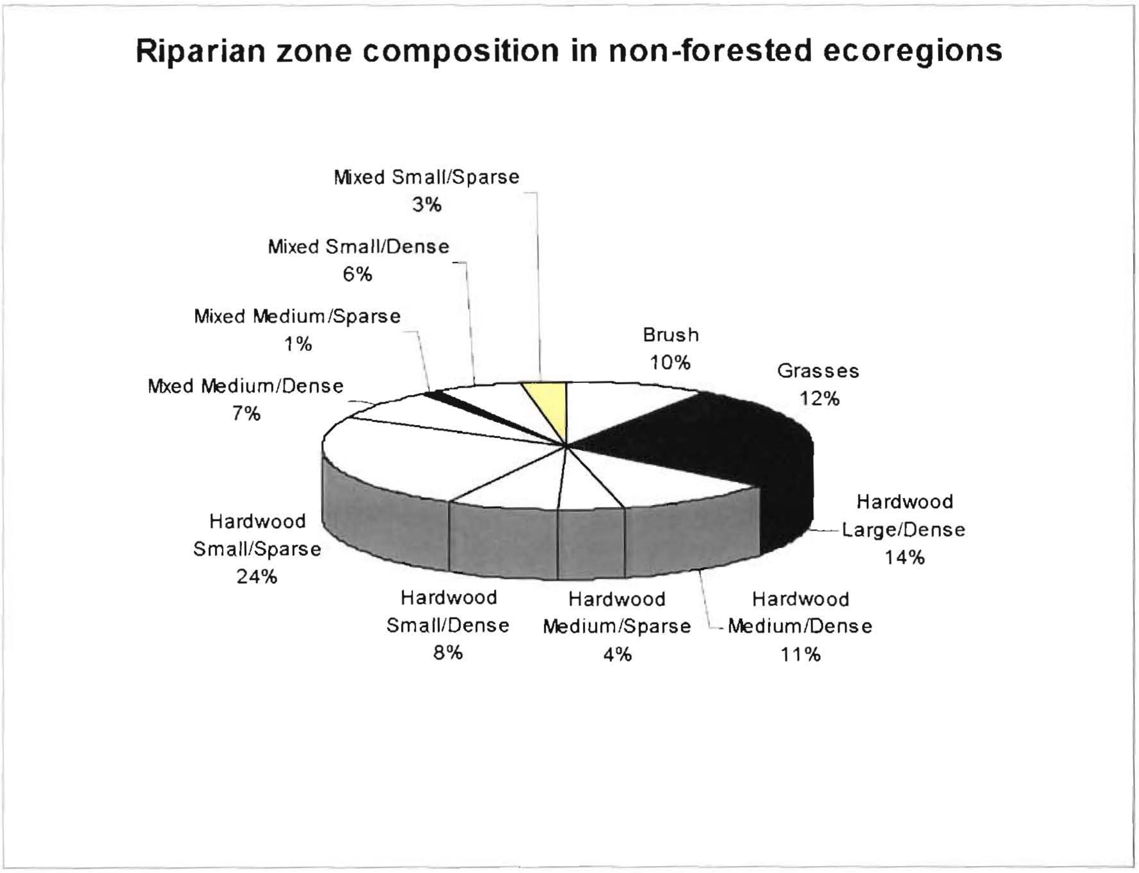


Figure 5.1. Riparian zone composition in non-forested ecoregions of the lower Molalla River and Milk Creek watershed, Oregon.

non-forested ecoregions would have supported dense stands of large hardwoods, including cottonwood, Oregon ash, and bigleaf maple (WPN 1999, Ecoregion Appendix). Currently, vegetation within most of these riparian zones is composed of grasses and shrubs or young-aged and thinner tree stands. These riparian areas largely occur on the lower elevation valley floors, where riparian vegetation has historically been cleared and channels have been modified for agricultural purposes.

Within the forested ecoregion portions of the watershed (represented by the Valley Foothills (3d), the Western Cascades Lowlands and Valleys (4a), and the Western Cascade Montane Highlands (4b)), riparian conditions also varied widely, but are represented by a large proportion of partially intact riparian zones composed of hardwoods and conifers (Table 5.5, Figure 5.2). Almost 10% of these riparian areas were dominated by brush and grasses, and almost half of these areas supported only small trees (Table 5.5, Figure 5.2). Historically, riparian zones occurring in all of these ecoregions supported medium to large-sized, mixed stands of hardwoods and conifers in the riparian zone; upland areas supported large dense stands of either conifers or had a mixed composition (WPN 1999). Clearing for agricultural development and timber harvest operations are largely responsible for the alteration in riparian condition classes in these portions of the watershed occurring within forested ecoregions.

Invasive species, particularly Himilayan blackberry and Japanese knotweed, are becoming increasingly common along the lower reaches of the watershed. Although addressing this particular issue is beyond the scope of this assessment, inventory and control of invasive species within

Table 5.5. Number of miles of riparian zone vegetation condition classes by subwatershed in the 3d, 4a, and 4b (i.e., forested) ecoregions of the lower Molalla River and Milk Creek watershed, Oregon. The headings in bold, medium/dense hardwood & mixed forests, are the predominant natural riparian zone condition in the 3d and 4a ecoregions.

	Non-forested		**Hardwood Forest**					**Mixed-species Forest**				
Subwatershed	Brush	Grasses	Large/Dense	**Medium/Dense**	Medium/Small	Small/Dense	Small/Sparse	**Medium/Dense**	Medium/Small	Small/Dense	Small/Sparse	Total
Canyon	1.8	0.3		**7.7**	0.5	0.5		**22.8**		19.7	1.6	54.8
Headwaters Milk Cr	2.2			**12.1**		1.2		**23.6**		11.3	1.0	51.3
Lower Milk Creek	3.4			**2.4**	1.0	0.9		**25.0**	4.9	35.8	4.3	77.7
Middle Milk Ck	5.5		0.9		0.3	0.8	2.2	**21.9**	1.1	13.2	3.2	49.1
Molalla R/Cedar Ck	11.7			**4.1**		0.9	2.5	**23.6**	1.6	18.9	2.8	66.1
Molalla R/Willamette								**1.1**				1.1
Upper Milk Ck	8.1			**1.8**	1.7			**31.7**	2.1	14.3	5.1	64.7
Woodcock Ck		1.5		**5.9**	2.1	1.5		**6.4**		12.7		28.5
TOTAL	32.6	1.8	0.9	**33.9**	5.5	5.8	4.6	**156.0**	9.7	125.9	18.0	394.6

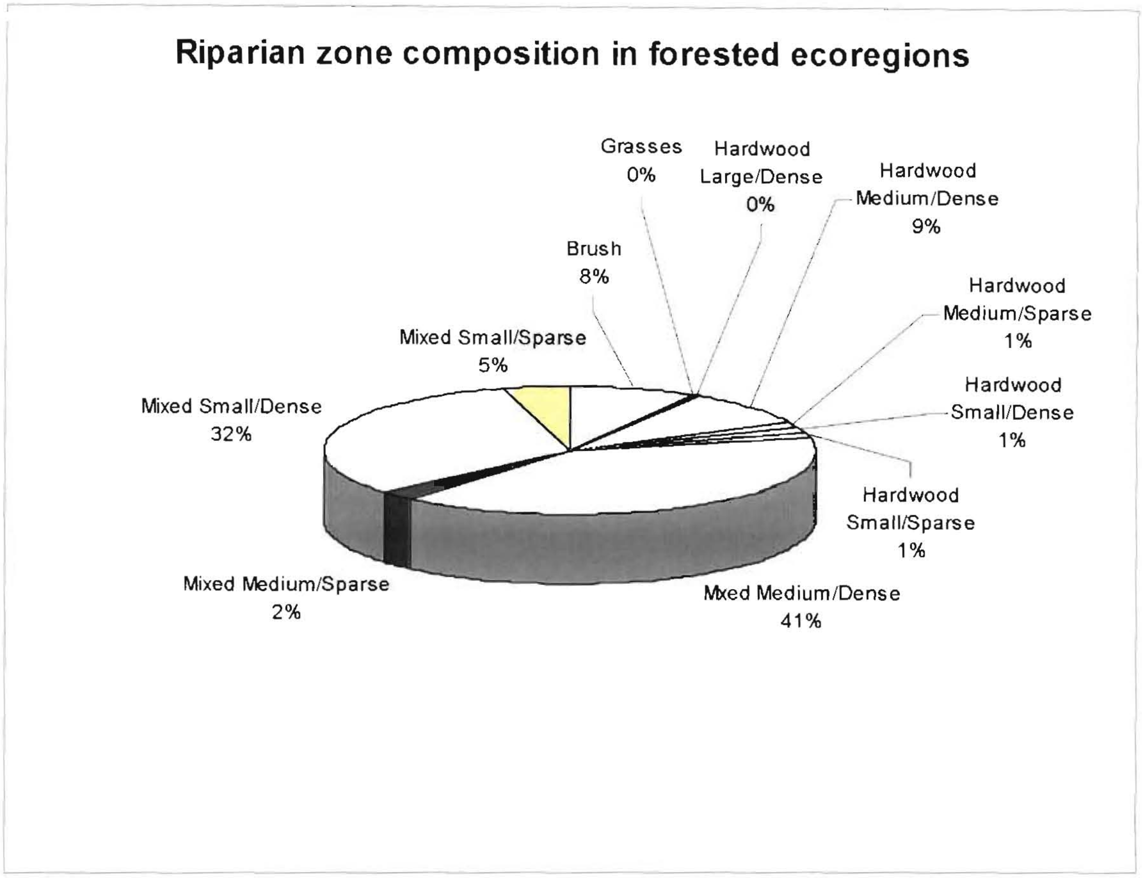


Figure 5.2. Riparian zone composition in forested ecoregions of the lower Molalla River and Milk Creek watershed, Oregon.

the watershed should be among priority issues to ensure that invasive species do not continue to spread throughout riparian zones in the watershed.

RIPARIAN RECRUITMENT POTENTIAL AND SITUATIONS

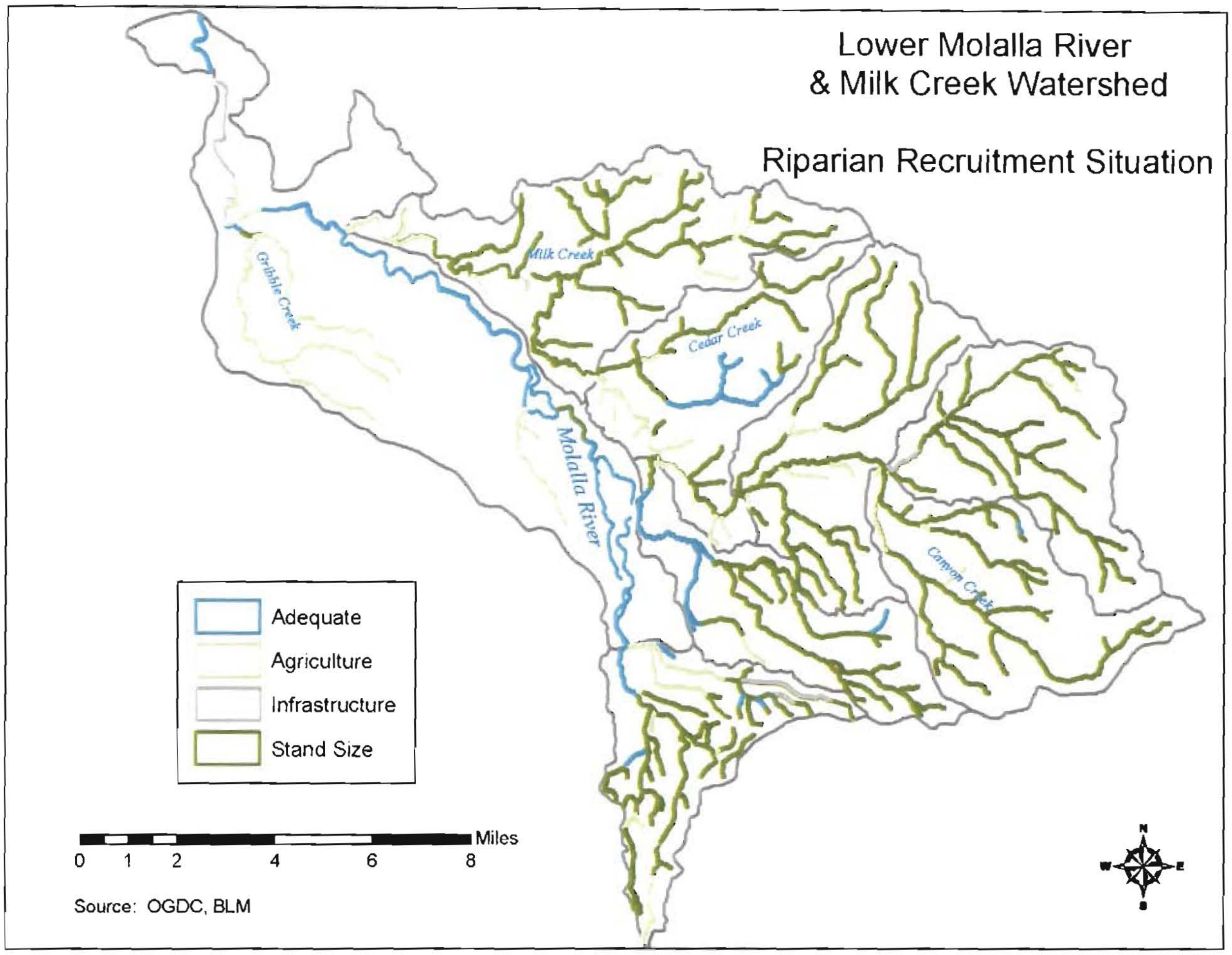
Across the watershed, riparian recruitment potential was adequate in only 11% of the total riparian area assessed (Table 5.6; Figure 5.3), indicating that most of the watershed riparian zones do not support sufficient quantities of trees to provide adequate supplies of woody materials to stream channels. Furthermore, the watersheds where most of the adequate conditions occur (Middle Milk Creek, Molalla River/Willamette, and Woodcock Creek) are dominated by the non-forested ecoregions, where riparian wood recruitment is naturally not as significant a factor as in forested ecoregions.

Forestry, a high-value land use in the watershed, is the largest factor affecting riparian recruitment potential by limiting tree sizes. 67% of the stream area throughout the watershed was limited by small stand size (Table 5.6). Stands of smaller trees result either from recent forestry activities (harvest, replanting) or succession of fallow or replanted agricultural land. If allowed to attain larger tree sizes, these situations will eventually produce adequate amounts of LWD; however, if current management practices continue, large proportions of small tree sizes will persist and continue to deplete streams of important woody structural components.

Agricultural practices, including valley floor farms and rangelands along streams have prevented trees and shrubs from becoming

Table 5.6. Riparian recruitment potential and situation by subwatershed in the lower Molalla River & Milk Creek watershed, Oregon.

			Inadequate							
	Adequate		**Agriculture**		**Infrastructure**		**Small stands**		**Wetland**	
Subwatershed	**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**
Canyon Creek	2467	0.8%	19038	6.3%	1440	0.5%	280493	92.4%	0	0.0
Headwaters-Milk Ck	0	0.0%	7762	2.7%	15158	5.3%	263218	92.0%	0	0.0
Lower Milk Cree	0	0.0%	81095	18.9%	3908	0.9%	344455	80.2%	0	0.0
Middle Milk Ck	47734	17.3%	75347	27.2%	0	0.0%	153430	55.5%	0	0.0
Molalla R/Cedar Ck	30324	7.7%	76150	19.3%	16341	4.1%	272325	68.9%	0	0.0
Molalla R/Willamette	159915	38.3%	230115	55.1%	17991	4.3%	9262	2.2%	0	0.0
Upper Milk Ck	0	0.0%	38534	11.0%	0	0.0%	312168	89.0%	0	0.0
Woodcock Ck	60722	22.9%	7780	2.9%	0	0.0%	197138	74.2%	0	0.0
TOTAL	301162	11.1%	535821	19.7%	54838	2.0%	1832489	67.3%	**0**	**0.0**



Source: OGDC, BLM

Figure 5.3. Riparian recruitment situations occurring in the lower Molalla River and Milk Creek watershed, Oregon.

reestablished. Nearly twenty percent of the watershed's riparian recruitment potential is limited by the presence of agriculture in the uplands (Table 5.6). It is recognized that the bottomlands along streams can be the most valuable agricultural land in the basin; however, encouraging a larger buffer between land uses and streams will benefit water quality and stream health, which also have values for landowners in the basin (Elmore 1992).

Roads comprised the majority of the infrastructure (INF) riparian recruitment situation; 2% of the basin's streams were affected in this manner (Table 5.6). Gravel quarries, bridges, and parking lots comprised a smaller portion of the result. In a partially urbanized watershed, these factors are difficult to mitigate for, as a substantial investment has already been made in the existing infrastructure, and it often doesn't make economic sense to abandon these projects for the sake of increasing woody debris in streams. Thus, these areas tend to get 'written off', and areas elsewhere are needed to mitigate for their existence.

Only a small portion of the RCUs assessed indicated wetland conditions as a secondary factor limiting riparian recruitment; no RCU had wetland conditions as the primary limiter of recruitment. These areas of saturated, anaerobic soils prevent the establishment of tall tree cover; instead wetland shrubs and grasses form a permanent cover. These areas are lacking in LWD, however the existence of functioning wetlands offsets the lack of LWD source trees, since they contribute to higher summer flows and help to buffer winter flooding.

STREAM SHADING

Stream shading varied across the watershed (Table 5.7). Generally, headwater stream reaches at higher elevations were more heavily shaded owing to the forested nature of these areas (Figure 5.4). Twenty-five percent of the riparian zone distance surveyed had stream shading of less than 40%; this primarily occurred in the lowlands where riparian vegetation has been cleared for agricultural purposes. Improvements in riparian conditions would increase stream shading and help abate elevation of summertime water temperatures. Because water temperature is an important determinant of biological stream conditions and a number of stream segments in the watershed violate state standards, reestablishing desirable riparian conditions and shading should be a priority in the watershed.

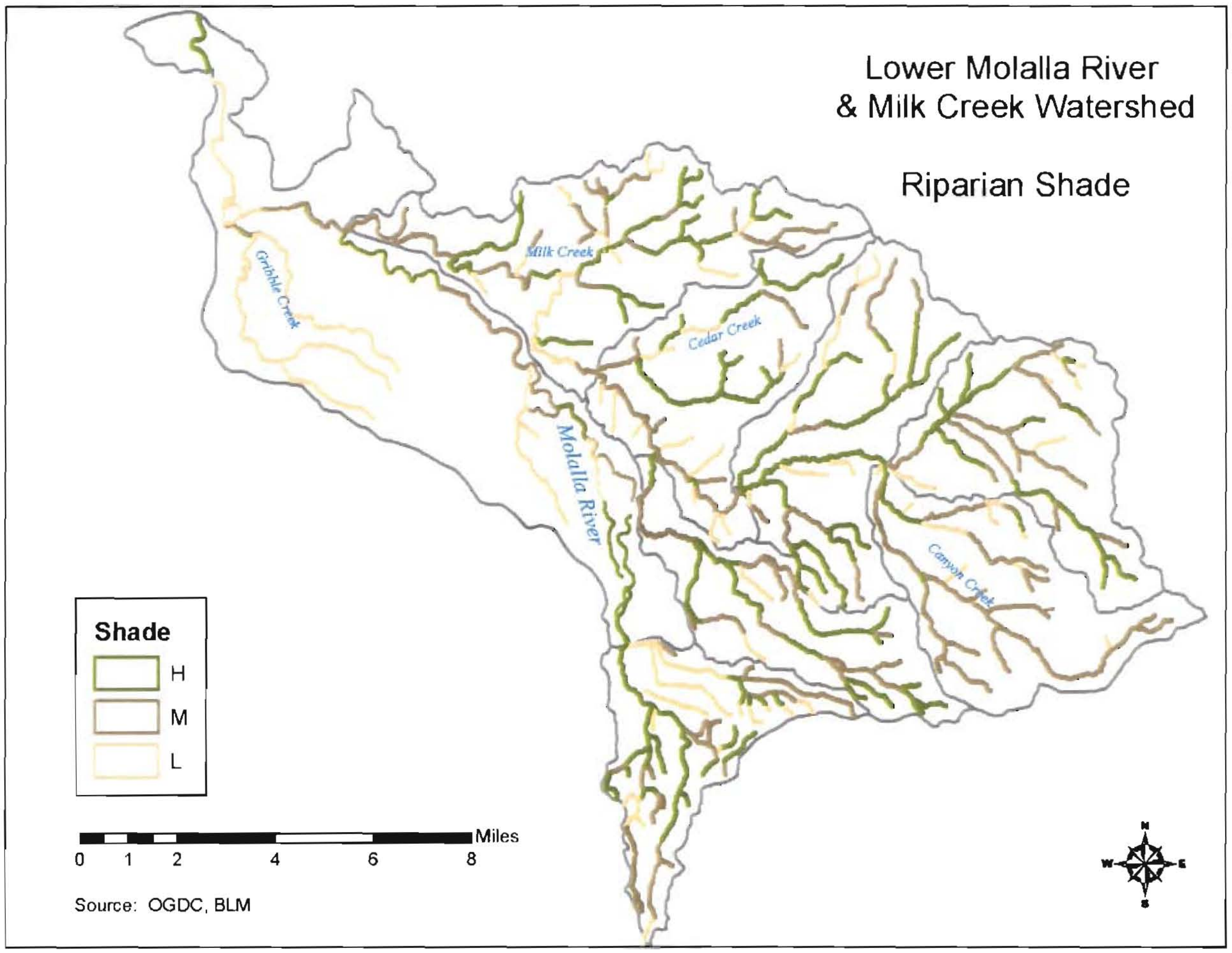
WETLANDS

According to information provided by the BLM, approximately 391 acres of wetlands occur in the LMR&MC watershed (Table 5.8). Most of these acres occur in the upper Milk Creek, Canyon Creek, and Molalla R./Cedar Creek subwatersheds (Figure 5.5). Most wetlands mapped in the watershed are immediately associated and contiguous with stream channels, which provide particularly important habitat during high flow events, allowing juvenile salmonids to take refuge from high velocity and turbulent waters occurring in river and stream channels.

Wetlands almost certainly were more extensive historically in the watershed than they are currently. An estimated 75% of wetlands have been lost from the Pacific Northwest due to human disturbance (US Fish and Wildlife Service and Canadian Wildlife Service 1990). Further losses of wetlands should be avoided in the watershed to avoid further loss of critical functions these areas provide.

Table 5.7. Linear distances and relative proportions of stream shading classes occurring within each subwatershed within the lower Molalla River & Milk Creek watershed, Oregon.

	Light Shade (≤40%)		**Medium shade (40–70%)**		**Heavy Shade (>70%)**		
Subwatershed	**ft**	**%**	**ft**	**%**	**ft**	**%**	**Total (ft)**
Canyon Creek	44,888	14.8%	235,073	77.5%	23,477	7.7%	303,438
Headwaters-Milk Ck	32,282	11.3%	134,349	47.0%	119,507	41.8%	286,138
Lower Milk Cree	89,104	20.7%	170,235	39.6%	170,119	39.6%	429,458
Middle Milk Ck	74,016	26.8%	94,942	34.3%	107,553	38.9%	276,511
Molalla R/Cedar Ck	113,312	28.7%	141,998	35.9%	139,830	35.4%	395,140
Molalla R/Willamette	260,712	62.5%	79,286	19.0%	77,285	18.5%	417,283
Upper Milk Ck	62,300	17.8%	74,610	21.3%	213,792	61.0%	350,702
Woodcock Ck	18,642	7.0%	113,486	42.7%	133,512	50.3%	265,640
TOTAL	695,256	25.5%	1,043,979	38.3%	985,075	36.2%	2,724,310



Source: OGDC, BLM

Figure 5.4. Stream shade classes occurring in the lower Molalla River and Milk Creek watershed, Oregon.

Table 5.8. Wetland acreages occurring within subwatersheds within the Lower Molalla River & Milk Creek watershed.

SUBWATERSHED	ACRES
CANYON CREEK	86.8
HEADWATERS MILK CREEK	24.8
LOWER MILK CREEK	33.4
MIDDLE MILK CREEK	13.3
MOLALLA RIVER / CEDAR CREEK	86.8
MOLALLA RIVER/WILLAMETTE RIVER	0.8
UPPER MILK CREEK	143.4
TOTAL	**391.0**

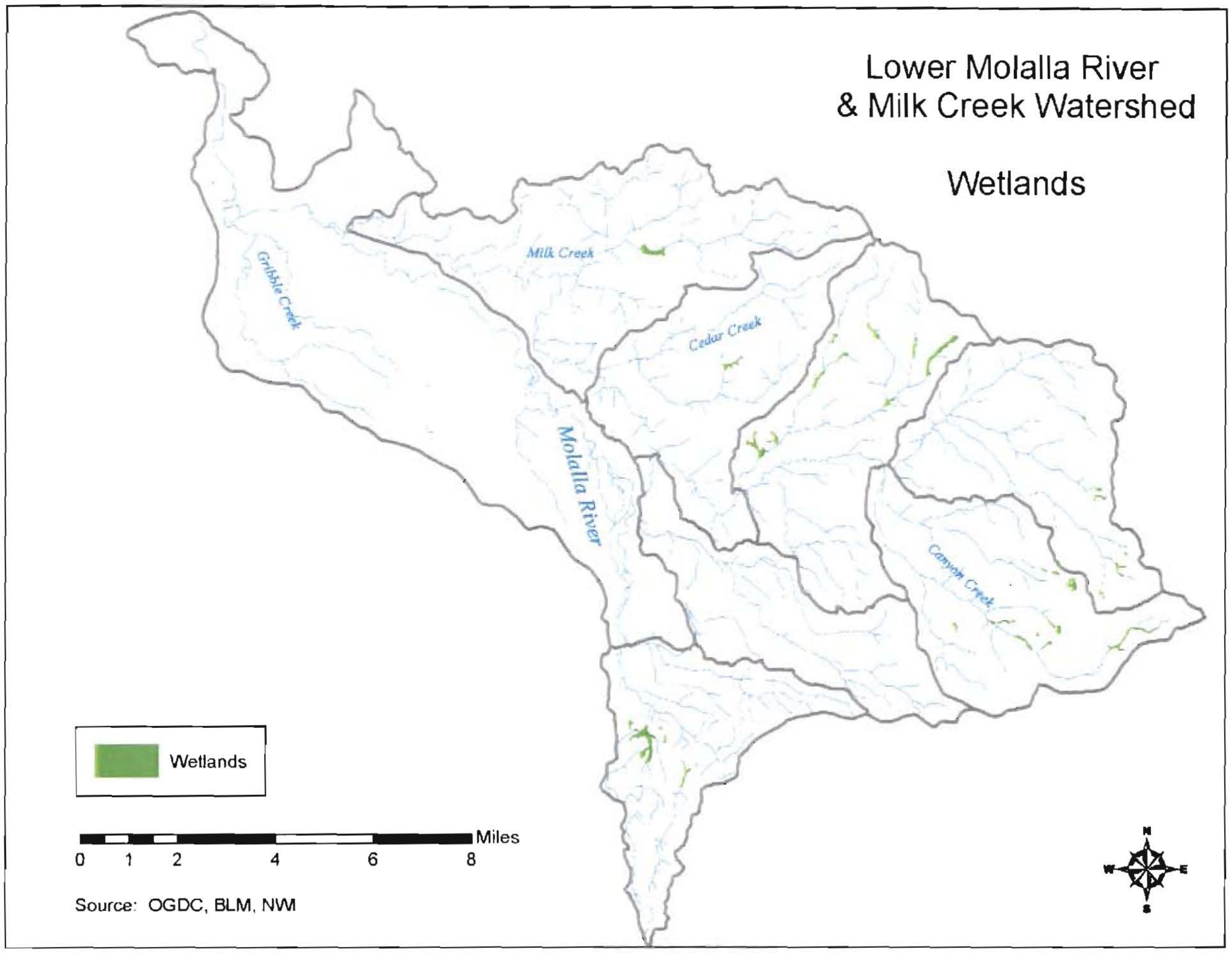


Figure 5.5. Locations of mapped wetlands occurring in the lower Molalla River and Milk Creek watershed, Oregon.

CONCLUSIONS AND RECOMMENDATIONS

Forestry, agriculture, and settlement patterns have altered riparian zone conditions throughout the Milk Creek / Lower Molalla River watershed. These changes have resulted in reductions in stream shading and riparian recruitment of large woody debris. Riparian zones occurring in upper reaches of stream networks that occur in primarily forested areas are currently being limited by small tree sizes or a lack of trees altogether. Riparian zones occurring on lower reaches and on the mainstem are frequently devoid of significant tree cover, which is necessary to absorb the energy of high winter flows and provide habitat for salmonid species.

Protection and restoration of riparian zones within the watershed would provide significant benefits to physical, chemical, and biological conditions. To this end, we recommend that landowners be encouraged to remove riparian areas from agricultural practices, including cropping and grazing. Riparian fencing can effectively exclude livestock from riparian areas and allow vegetation to regenerate. Planting of woody riparian vegetation will expedite and enhance recovery of the riparian zone.

In forested areas of the watershed, a combination of increased harvest rotation and increased protection of riparian-area tree cover would benefit water quality and quantity in the stand-size limited areas. Large areas of the watershed are within this classification, and would benefit from these actions.

This watershed-wide, screening-level assessment provides a starting point for characterizing riparian zone conditions in the watershed. A more thorough assessment could include examination of historic photographs and survey notes to better characterize historic riparian zone conditions and to prescribe more specific targets for desirable riparian zone conditions. We also recommend collection of more field data to quantify current riparian zone conditions, particularly in areas of the watershed where conditions could be best improved by riparian restoration and replanting.

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CHAPTER SIX: SEDIMENT SOURCES

INTRODUCTION

Erosion and the delivery of sediment into streams are natural processes, and the presence of sediment in rivers and streams is a natural characteristic of these open systems. An inherent quality of open systems such as rivers and streams is their ability to self regulate. Rivers and streams are in a constant flux between the amount of sediment delivered and available for transport and the range of discharges with the ability to entrain and transport this material through the watershed. In natural river and stream systems an approximate equilibrium is maintained between these two processes resulting in a relatively stable system. Alterations to land cover and hydrology by human activities can result in increased sediment loading into streams from either hillslope or channel sources. The primary sources of stream sediment include erosion of uplands (hillslope sources), lateral movement of channels into streambanks (bank erosion), and downcutting of streambeds (Waters 1995).

Sediment is widely recognized as the single greatest pollutant of streams in the United States in terms of quantity involved (Waters 1995). Additionally, the U.S. Environmental Protection Agency has identified sediment as the most important cause of river and stream pollution in the United States in terms of miles of rivers and streams polluted (EPA 1990). Still, separating excessive sediment loading resulting from human activities from that resulting from natural background levels and rates can be challenging, particularly with a lack of baseline information.

Excessive sediment in streams has been well documented to negatively affect aquatic life and habitats. Fine sediment deposited on spawning gravels can reduce the survival of eggs and other early life stages of fish. Filling in of gravels and other fine substrates also reduces habitat available to benthic life and may lead to decreases in macroinvertebrate densities. Suspended sediment also can affect fish and macroinvertebrates by accumulating on gill and other respiratory surfaces, and by disrupting or altering social and feeding behaviors.

TRANSPORT PROCESSES

Primary sources of stream sediment include erosion of uplands, lateral movement of channels into streambanks (bank erosion), and downcutting of streambeds (Waters 1995). Most sediment delivery and transport takes place during peak flows when velocities and turbulence reach higher levels, greater turbulence results in more entrainment and greater velocities result in higher transport ability. Velocity, turbulence, and discharge increase proportionately with rising river stage; these components of stream power continue to increase until a threshold is reached. Stream banks and sediment deposits within stream channels resist erosion through inherent cohesive properties. As flows and stream power increase, the force of water acting on the material's cohesive property also rises, resulting in shear stress on these materials. When shear stress reaches a given threshold, the cohesion of the material fails, turbulence entrains the material and the higher velocity maintains transport.

Hillslope processes include natural surface erosion and runoff from the surrounding watershed, mass wasting events and landslides. Anthropogenic hillslope sources of surface erosion can include agricultural areas, timberlands and roads. Surface erosion occurs when rainfall intensity exceeds the absorption capacity of the soil, resulting in surface runoff which carries with it suspended sediment. Forestry and agricultural practices such as vegetation removal and soil compaction can reduce absorption capacities of soils and increase both surface runoff and erosion.

Roads and road construction can also contribute significant quantities of sediment to streams. Roads tend to concentrate sediment-laden runoff directly to streams through ditches and culverts. In the absence of roads the majority of sediment incorporated into runoff is filtered out as it travels over the forest floor. In forested areas road grade construction frequently cuts the uphill material and sidecasts the material on the downhill-slope side of the road to create a flat driving surface. The cohesion of sidecast material and the cutslope is weakened through this disturbance. Cutslope and sidecast road construction can often result in slumping and slope failure. These conditions can often lead to failure of the entire road prism especially when practiced on steep slopes. As a result roads can often intensely increase the potential for large amounts of sediment to be delivered to streams.

Channel sediment sources include bank erosion, channel down cutting and debris flows. Bank erosion, or bank sloughing, occurs by lateral migration of a stream channel into its streambanks. Bank failure and sloughing as previously discussed results from the shear stress of hydraulic pressure applied by lateral movement of the stream increasing beyond the cohesive strength of the bank material. Channel downcutting is a primary process of stream function and over geologic time results in the valleys and landforms associated with stream systems today. Gravity combines with the properties of water to transport material from within the stream channels path carrying and depositing it downstream. Debris flows occur when landslides enter streams during storm events. As these materials are carried downstream, they may grow in size by incorporating existing stream channel materials, including logs, boulders, and other debris.

In this chapter potential sediment sources to streams within the Lower Molalla River Watershed are assessed and discussed. In this assessment potential sediment sources include slope instability, rural road runoff and runoff from agricultural croplands.

METHODS

INTRODUCTION

Three major sediment sources were selected and prioritized for further assessment owing to their likelihood of contributing to the total sediment load within the lower Molalla River and Milk Creek watershed. These sources include rural and forest road runoff, slope instability, and agricultural lands. This assessment primarily encompassed GIS analysis, supported by field reconnaissance and inspection of multiple years of aerial photos. GIS layers used in this analyses were provided by the USBLM Salem, OR district office, the USGS GIS data clearinghouse, the Oregon state geospatial data clearinghouse and the Oregon Department of Geology and Minerals in cooperation in part with the Portland State University. Aerial photos from 1936 and of the 1996 flood event were provided by the US Army Corps of Engineers. BLM provided photos from 1998 and 2001. The USGS provided digital-ortho quads.

RURAL AND FOREST ROAD RUNOFF

The potential for rural and forest roads to contribute sediment to streams in the watershed was assessed using stream and road data layers in GIS. In this basic assessment, total road lengths and total stream lengths were first calculated for each subwatershed. The lengths of roads occurring within 200 feet of streams were identified and then summed for each subwatershed. In this assessment, we assumed that a higher proportion of roads within 200 feet of streams (relative to total stream miles occurring in the subwatersheds) would indicate that roads were likely contributing higher sediment loads to streams. Further, roads with steep side slopes (greater than 50%) uphill of the road usually have more sediment accumulating in the road ditches. Therefore, we also calculated the length of roads that were both within 200 feet of streams and that had uphill slopes of greater than 50%. These two variables, combined, were used to determine the relative risk of roads delivering sediment to streams within each subwatershed.

SLOPE INSTABILITY

The potential for slope instability to contribute to elevated sediment loading in the watershed as a result of slope failure in close proximity to streams was assessed using GIS data layers and aerial photos. Stream lengths occurring both within areas of steep slope (>50%) and in potential debris flow hazard zones were identified and summed within each subwatershed. Potential debris flow hazard zones were obtained from the Oregon Department of Geology and Minerals. We assumed that streams occurring within these potentially unstable areas are most at risk of elevated sediment loading from slope failures. We used these data for the final index of slope instability contributing to elevated sediment loading within each subwatershed.

CROPLANDS

The potential for runoff from crop lands to contribute to sedimentation problems in the watershed was screened using GIS data layers and aerial photographs. Cropland acreages within each subwatershed were calculated and summed. Stream reach lengths occurring adjacent to these areas were then identified and summed within each subwatershed. We assumed that larger lengths of stream occurring adjacent to croplands would correlate with a greater risk of elevated sediment loading from croplands into streams within each subwatershed.

RESULTS

RURAL/FOREST ROAD RUNOFF

Watershed wide, 18.6% of rural and forest roads occur within 200 feet of streams (Table 6.1), while 0.4% of rural and forest roads both occurred within 200 ft of streams and occurred on uphill hillslopes exceeding 50%. The results of this basic assessment suggest that the Canyon Creek subwatershed likely poses the greatest risk of elevated sediment delivery from road runoff with 0.08 mi/mi^2 of roads within 200 ft of streams and on >50% hillslopes (Table 6.1). The Molalla River/Cedar Creek, Middle Milk Creek, and Headwaters Milk Creek watersheds are all likely at greater risk of elevated sediment loading from road runoff owing to their higher densities of high-risk road segments than occur in Lower Milk Creek, Upper Milk Creek, Woodcock Creek, or the Molalla River subwatersheds (Table 6.1). The Molalla River subwatershed likely poses the lowest risk with no higher-risk road segments occurring in the subwatershed.

This basic assessment does not include more detailed information describing road conditions, such as road surface material or frequency of traffic use, precluding a more detailed or definitive assessment of the risk of rural and forest road runoff delivering elevated sediment levels to watershed streams. This screening level assessment should be used focus on areas containing higher densities of these higher-risk roads, where more detailed assessments could be performed to better evaluate these risks.

Table 6.1. Lengths of road within 200 feet of streams, and lengths of road occurring on hillslopes of >50% within 200 feet of stream in the lower Molalla River and Milk Creek watershed, Oregon.

	Road Lengths	Road Densities	Roads <200 ft from streams		Roads <200' from stream & slope >50%	
Subwatershed	(miles)	(mi./mi.2)	Length (mi)	Density (mi./mi.2)	Length (mi.)	Density (mi./mi.2)
Canyon Creek	104.1	6.2	18.8	1.1	1.398	**0.083**
Headwaters Milk Creek	134.5	8.4	18.2	1.1	0.376	**0.024**
Lower Milk Creek	101.4	4.6	24.4	1.1	0.120	0.005
Middle Milk Creek	62.8	3.9	15.5	1.0	0.488	**0.031**
Molalla River	168.0	3.9	8.1	0.2	0.000	0.000
Molalla River/ Cedar Creek	52.9	4.1	19.5	1.5	0.576	**0.045**
Upper Milk Creek	80.0	4.4	18.8	1.0	0.128	0.007
Woodcock Creek	61.5	4.8	19.1	1.5	0.102	0.008
Totals (* indicates mean)	765.3	4.85*	142.3	0.9*	3.187	0.020*

SLOPE INSTABILITY

The Lower Molalla River and Milk Creek watershed contains 9.31 square miles of potential debris flow hazard areas, representing 6% of the total watershed area of 157.6 square miles (Table 6.2). More than 36 miles of streams occur within these debris flow hazard zones. Most of the debris flow hazard areas are classified as only moderate risk areas, as only 0.04 square miles of high risk areas occur in the watershed. Subwatersheds most at risk of increased sediment delivery to streams as a result of debris flow are Canyon creek, Headwaters Milk creek and Molalla River/Cedar Creek with 10.4, 8.4 and 7.6 miles of stream within debris flow hazard areas, respectively (Table 6.2). These three watersheds also contain the highest proportions of debris flow hazard zones, largely a result of the prevalence of steeper hillslopes and topography in these areas. Overall, the watershed is at relatively low risk of significant sedimentation problems resulting from slope instability, as only 0.03% of the watershed is classified as being at high risk for debris flows.

CROPLAND

The Molalla watershed contains 40 square miles of croplands within which 92.14 miles of streams occur (Table 6.3). The Molalla subwatershed, alone, contains 35.8 square miles of croplands within which 68.08 miles of streams occur. The Lower Milk creek subwatershed contains 2.97 square miles of croplands, the only other subwatershed with more than 10% of its land use occurring as cropland. The Canyon creek and Headwaters Milk creek do not contain any croplands and the remaining four subwatersheds combine to contain only 1.18 square miles of croplands. The greatest risk of increased sediment

Table 6.2. Occurrence of debris flow hazard zones and streams within debris flow hazard zones in the lower Molalla River and Milk Creek watershed, Oregon.

			Moderate debris flow hazard		High debris flow hazard		
Sub Watershed	**Area (mi^2)**	**Streams (mi)**	**(mi^2)**	**% Area**	**(mi^2)**	**% Area**	**Streams within Debris Flow Zones (mi)**
Canyon Creek	16.9	55.9	2.86	17%	0.03	0.20%	10.43
Headwaters Milk Creek	15.9	67.2	2.39	15%	0.01	0.04%	8.41
Lower Milk Creek	22.0	109.9	1.01	5%	0.00	0.00%	3.95
Middle Milk Creek	16.0	75.4	0.88	6%	0.00	0.00%	3.69
Molalla River	42.8	69.7	0.19	0%	0.00	0.00%	0.09
Molalla R/Cedar Creek	12.9	65.0	1.37	11%	0.00	0.00%	7.63
Upper Milk Creek	18.4	84.7	0.48	3%	0.00	0.00%	2.09
Woodcock Creek	12.8	61.9	0.09	1%	0.00	0.00%	0.26
Totals	157.6		9.27	6%	0.04	0.03%	36.56

Table 6.3. Occurrence of croplands in the lower Molalla River and Milk Creek watershed, Oregon.

Subwatershed	**Area (mi^2)**	**Crop lands (mi^2)**	**Crop lands %**
Canyon Creek	16.90	0.00	0%
Headwaters Milk Creek	15.94	0.00	0%
Lower Milk Creek	21.99	2.97	14%
Middle Milk Creek	15.95	0.11	1%
Molalla River	42.79	35.81	84%
Molalla River/ Cedar Creek	12.87	0.44	3%
Upper Milk Creek	18.36	0.38	2%
Woodcock Creek	12.83	0.24	2%
Totals	157.63	39.96	25%

loading to streams from cropland runoff occurs in the Molalla River/Willamette subwatershed. Further efforts to assess the effects of agricultural practices on delivery of sediment into watershed streams should focus on this subwatershed.

DISCUSSION AND RECOMMENDATIONS

Increases in sediment loading into streams within the LMR&MC watershed occur from several sources, including forest and rural roads, agricultural lands, forestry activities, and mass wasting events. In this screening-level assessment, the relative risk that each of these potential sources poses in each subwatershed was assessed. More detailed analyses could be performed using more field-based information to further identify leading contributing factors to sedimentation of the watershed.

Our analyses indicate that agricultural activities likely only pose a significant risk in the Molalla/Willamette subwatershed. However, actual sediment loading into streams from these activities is unknown and would have to be further evaluated with ownership-specific information such as crop cover type, soil type, field conditions, and farming practices. Additionally, field visits are required to determine whether storm events that mobilize sediments coincide with the cropland being vulnerable to erosion. Generally, the potential for severe erosion on agricultural lands is greatest during periods of intense rainfall and conditions of low infiltration capacity. These conditions most frequently occur in the Molalla River watershed in the winter months when soils are saturated and winter storms occur. Frozen ground, snow cover, or sealing of soil surfaces by raindrops can further reduce infiltration capacity on unprotected croplands. Any further investigations of the effects of agriculture on sedimentation of streams in the watershed should focus on gathering site-specific information during periods of intense rainfall.

Our analysis indicated that roads posed the most significant risk of increased sediment delivery to streams in the Canyon Creek and Molalla River/Cedar Creek subwatersheds. Roads can increase sediment loading into streams by both surface erosion and mass wasting. Our screening-level assessment did not include an evaluation of the risk of road failures contributing to sediment loads, but should be considered for future investigation. Our assessment did not include location-specific information on road size, conditions, surface material, or traffic, which are all necessary to better quantify the risk of increased sedimentation of streams in the watershed. Further efforts to quantify the effects of roads on sedimentation of streams in the watershed should include this type of information. Because so little federal or state land occurs in the watershed, no comprehensive road inventories have been performed, leaving a significant data gap that precludes further assessment these risks.

Forest road construction and use has historically been a significant contributor to increased sediment loading and other altered hydrologic processes on forested lands. The Oregon Department of Forestry now has established guidelines to help locate roads and landings to minimize impacts to streams. Efforts to minimize erosion on forest roads can include locating roads away from streams and planning to minimize the extent, width, and period of use. Following construction, proper maintenance and operation, including reducing wet weather traffic, decommissioning, upgrading and maintaining culverts, and placing rock on unsurfaced roads, can reduce erosion.

Channel sediment sources, including bank erosion and channel downcutting, were not evaluated in this screening-level assessment, but warrant some treatment. Bank erosion, or bank sloughing occurs during high flow events and is caused by the force of the water (shear stress) exceeding the bank materials' cohesiveness. Channel downcutting can also redistribute sediments within the drainage network. Data describing channel conditions for the LMR& MC watershed are scarce, precluding any quantitative evaluation of the condition of these channels or of their likelihood of contributing to elevated sediment loading. Anecdotally, ABR field visits generally indicated that many tributary streams to Milk Creek and the Molalla River were minimally incised and did not have heavily embedded substrates, particularly those higher-gradient streams occurring on the east side of the watershed. Further investigation of stream channels is needed to better evaluate the watershed conditions with respect to sedimentation and fouling of stream substrates.

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CHAPTER SEVEN: CHANNEL MODIFICATIONS

INTRODUCTION

Channel modification occurs when human alteration results in a change in the physical or hydrologic properties of the stream channel. This component of the assessment identifies existing channel modifications that are affecting channel morphology and hydrologic properties in the Lower Molalla River & Milk Creek (LMR&MC) watershed and assesses the likely effects of these modifications. In the watershed, channel modifications include channelized stream segments, roads that restrict lateral channel migration, earthen impoundments, and riprap. Because stream restoration projects are addressed in the Fish and Fish Habitat Assessment chapter and road crossings are addressed in the Sediment Sources chapter, neither is considered in this portion of the assessment, although each clearly modifies stream channels.

The history since Euro-American settlement of the LMR&MC watershed includes land uses that significantly impact the river and stream systems. Channel straightening and splash dams were a result of early twentieth century forestry practices. Straightening of river and stream channels was a common practice in the past to increase water velocity and move water through a stream reach more efficiently, thereby more quickly draining a given area and reducing local flooding. To understand how channelization affects rivers and streams, it is useful to view rivers as transporting machines (Leopold 1994). As such, rivers are dynamic systems that attempt to maintain a balance between sediment transport and the energy available from streamflow to perform work. River meanders develop to maintain a channel slope that allows energy to be expended a rate that results in channel stability; that is, the channel neither degrades nor aggrades (Rosgen 1996). Floodplain rivers and streams develop meanders along which energy is expended over longer distances than would be expended in a straight stream channel with the same vertical drop (i.e., steeper gradient). Straightened channels result in steeper channel gradients and produce accelerated water velocities that increase streambank and bed erosion and sedimentation. Channel incision and channel widening both can result from these processes and effectively disconnect the river or stream from its floodplain. Diking often accompanies channelization to further confine stream flows and prevent flooding of lands in agricultural production. This further disconnects the stream channel from its floodplain, thereby exacerbating the effects of channelization described above.

Dams also alter the natural situation of streams. High water events may be attenuated due to the storage capacity of the impoundment, while during late summer low flows, streams may dry up altogether downstream of a dam structure due to the extra storage. Fish passage is also an issue in these situations; small on-channel farm dams usually predate modern knowledge of fish passage issues, and thus rarely incorporate facilities that would pass fish safely.

Roads constructed near stream channels may impede or prevent lateral channel migration and produce some of the same effects caused by intentional channelization. In general, all of these activities have the potential to adversely affect stream health by increasing water velocity, decreasing floodplain function, decreasing water quality and quantity, and reducing fish habitat value (Leopold 1996).

METHODS

Channel conditions were evaluated using field assessments and aerial photos (see Chapter 5 – Riparian Conditions). Modifications were mapped using ArcView 3.2a and coded using the following fields:

Site Number – An individual code for the channel modification.

Activity – A brief description of the channel modification in question. Categories included Pond/Agricultural Impoundment, Riprap, Roaded, and Channelized.

CHT – Channel Habitat Type (see Chapter 3) of the stream impacted by the channel modification.

Length – Length, in feet, of the channel modification in question.

Degree of Impact – Subjectively coded as High, Medium, or Low impact, depending upon the nature of the channel modification.

Type of Impacts – Impacts of the channel modification in question upon riparian structure and function were coded as follows.

1. Migration barrier. Fish passage, both anadromous and for fish colonization / seasonal movement are compromised by the activity
2. Loss of spawning / rearing / escape habitat. Simplification of the channel reduces the amount of habitat available for the various life stages of fish species
3. Water quality. Agricultural impoundments can cause increased temperatures and higher nutrient loads in streams
4. Decreased floodplain function. Channelization disconnects the stream from its floodplain, increasing high water flows and depleting groundwater supplies.
5. Flow alteration. Impoundments and channelization change the hydrologic character of the stream, with ponds decreasing peak flows and channelization increasing flows.
6. Erosion potential. Roaded areas adjacent to streams can lead to increased surface runoff.

It should be noted that the resulting list is by no means a comprehensive listing of all of the channel modifications within the basin. Limitations of access and visibility on aerial photographs ensure that this exercise is a sampling of major modifications

RESULTS

Thirty-two channel modifications were identified in the watershed (Table 7.1, Figure 7.1). Channelization to provide drainage for agricultural areas (31,100 stream-ft) and roads adjacent to stream beds (55,828 stream-ft) were the primary types of channel modification occurring in the watershed (Table 7.2).

Nearly two-thirds of the channel modifications in the watershed occur in the lower reaches, in the Molalla River / Cedar Creek (33,470 str-ft, 36.4%), Molalla River / Willamette River (11,052 str-ft, 12.0%), and Lower Mik Creek (14,110 str-ft, 15.3%) subwatersheds. This is most likely a function of the agricultural nature of the lower watershed. (Table 7.3)

Table 4 lists the CHTs affected by the channel modifications within the watershed. 38.8% of the watershed (35,662 str-ft) falls under the MV CHT class (see Chapter 3), by far the most impacted CHT type in the watershed.

DISCUSSION AND RECOMMENDATIONS

Channel modifications that have occurred in the watershed have resulted primarily from agricultural activities and placement of road infrastructure. The most common of these modifications, channelization, has contributed to alteration of channel dimensions and entrenchment of a number of stream segments. The continued presence and function of these modifications will prevent reestablishment of more stable channel conditions in the LMR&MC watershed. Channel downcutting and alteration of flow regimes downstream of these areas will continue to result from these modifications.

Limited ground truthing and incomplete access to private lands precluded a comprehensive assessment of channel modifications in the watershed, but our current assessment likely provides a representative sample of the relative frequencies of different modification types occurring on the watershed and a good sense of what the most common problems associated with channel modification are in the watershed. Identifying smaller channel modifications on aerial photos also may have led to an underestimate of the relative frequency of tributary modifications. Future inventories of modifications should concentrate on landowner access, historical channel modifications, and past forestry practices to increase the pool of recognized modifications.

Likewise, the OWEB protocol does not include in its channel modification definition channels that become incised due to a change in the hydrology of the stream. With channelization, diking, and straightening of channels, water flows

Table 7.1. List of channel modifications identified in the Lower Molalla River and Milk Creek Watershed, Oregon. Site number corresponds to numbers on Figure 7.1.

Site No	Activity	CHT	Length (ft)	Degree of Impact	Types of Impact		
1	Riprap (failing)	FP1	1076	High	4	5	6
2	Channelized	MM	2681	High	2	4	5
3	Channelized	MM	4168	High	2	4	5
4	Channelized	LM	2701	High	2	4	5
5	Channelized	MM	3055	Moderate	2	4	5
6	Channelized	FP3	2988	High	2	4	5
7	Channelized	FP2	1697	High	2	4	5
8	Pond	MC	2802	High	1	3	5
9	Road	MH	644	Low	4	5	6
10	Road	LC	5616	Low	4	5	6
11	Road	MM	2787	Low	4	5	6
12	Road	MH	1185	Low	4	5	6
13	Channelized	LM	4523	High	2	4	5
14	Road	MV	5633	Low	4	5	6
15	Road	MC	2179	Low	4	5	6
16	Road	MV	18686	Low	4	5	6
17	Road	MV	4023	Low	4	5	6
18	Road	MV	6687	Low	4	5	6
19	Road	MC	426	Low	4	5	6
20	Road	MC	3190	Low	4	5	6
21	Road	MC	1823	Low	4	5	6
22	Road	FP2	386	Low	4	5	6
23	Road	FP2	1173	Low	4	5	6
24	Road	FP2	411	Low	4	5	6
25	Channelized	MH	864	Moderate	2	4	5
26	Channelized	MH	1426	High	2	4	5
27	Channelized	MH	1061	High	2	4	5
28	Road	LM	979	Low	4	5	6
29	Channelized	FP1	5934	High	2	4	5
30	Pond	FP3	433	High	1	3	5
31	Pond	MV	159	High	1	3	5
32	Pond	MV	475	High	1	3	5
	Total		91,872				

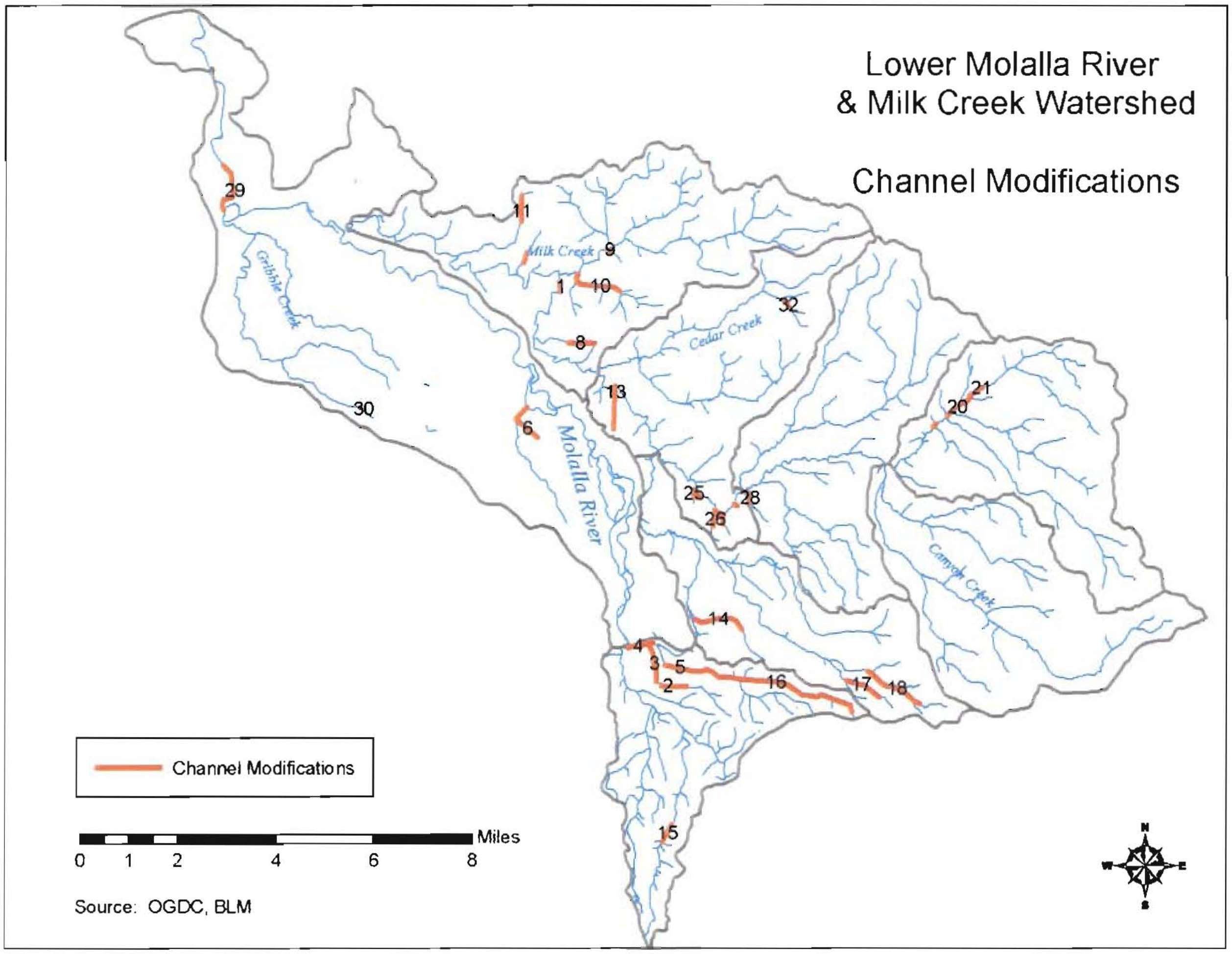

Figure 7.1. Locations of identified channel modifications.

Table 7.2. Summary of channel modifications by type of modification in the Lower Molalla River and Milk Creek Watershed, Oregon.

Modification Type	Total length (feet)
Channelized	31100
Pond	3868
Road	55828
Riprap	1076
Total	91872

Table 7.3. Summary of channel modifications by subwatershed in the Lower Molalla River – Milk Creek Watershed, Oregon.

	Length in Feet				
Subwatershed Name	Channelized	Pond	Road	Riprap	Total
Headwaters Milk Creek			5439		5439
Lower Milk Creek		2802	10232	1076	14110
Middle Milk Creek	7875	633	1970		10478
Molalla River / Cedar Creek	12605		20864		33470
Molalla River/Willamette River	10620	433			11052
Upper Milk Creek			979		979
Woodcock Creek			16343		16343
TOTAL	31100	3868	55828	1076	91872

Table 7.4. Summary of channel modifications by CHT impacted & subwatershed in the Lower Molalla River – Milk Creek Watershed, Oregon. CHT codes are those as defined in Chapter 3 – Channel Habitat Types.

	Channel Habitat Type									
Subwatershed Name	FP1	FP2	FP3	LC	LM	MC	MH	MM	MV	Total
Headwaters Milk Creek						5439				5439
Lower Milk Creek	1076			5616		2802	1830	2787		14110
Middle Milk Creek		1970			4523		3352		633	10478
Molalla River / Cedar Creek					2701	2179		9905	18686	33470
Molalla River/Willamette R	5934	1697	3421							11052
Upper Milk Creek					979					979
Woodcock Creek									16343	16343
TOTAL	7010	3667	3421	5616	8203	10420	5181	12692	35662	91872

out of the system with greater speed, and thus, energy, and can incise banks and beds until it reaches a new equilibrium (Chapter 4 – Hydrology and Water Use). When the headwaters of a watershed experience severe modification, the lowland stream systems suffer the consequences. Thus, when plans for restoration of the LMR&CW begin to develop, the health and function of the entire watershed must be accounted for. While some of the Channel Modifications will probably remain permanent features in the landscape, identification and prioritization of modifications that can be decommissioned should be a priority.

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CHAPTER EIGHT: WATER QUALITY

INTRODUCTION

The federal Clean Water Act (CWA) was passed and signed into law in 1972 with the mandate "to protect and maintain the chemical, physical, and biological integrity of the nation's waters." The Oregon Department of Environmental Quality (DEQ), under the authority of the Environmental Protection Agency, has the responsibility to set standards to protect water quality and to enforce these standards. The CWA requires each state to designate beneficial uses, determine what parameters to measure to ascertain whether beneficial uses are being met, and to develop criteria for those parameters.

Beneficial uses have been established by the Oregon Water Resources Department (WRD) for each major river basin in the state and listed in the Oregon Administrative Rules, Chapter 340 Division 41. The WRD has identified 15 beneficial uses in the Molalla River subbasin (Table 8.1); the Oregon Department of Environmental Quality is responsible for ensuring that these beneficial uses are being met. Federal law requires protection of the most sensitive of these beneficial uses. The most sensitive beneficial uses occurring in the Molalla River watershed are (AWQAC 2002):

- Resident fish and aquatic life
- Salmonid fish spawning and rearing
- Water contact recreation
- Public and private domestic water supply

In Oregon, the Department of Environmental Quality (DEQ) is responsible for developing water quality standards that will protect designated beneficial uses of waters of the state. Section 303(d) of the Clean Water Act requires each state to develop a list of water quality limited streams that violate these water quality standards. This list of water quality limited streams is reviewed, updated, and submitted to the US Environmental Protection Agency every two years. To warrant a listing, water quality criteria must be evaluated using sufficient data that both verify the violation and meet minimum quality assurance requirements. Because water bodies may often not have sufficient data that to allow a listing determination to be made, the 303(d) list may under represent the number of impaired water bodies in a given region or watershed. Watersheds lacking sufficient water quality monitoring programs are particularly likely to have streams that are not meeting standards, yet do not occur on the state's impaired water bodies list.

WATER QUALITY PARAMETERS

TEMPERATURE

Water temperature can significantly influence the distribution of aquatic organisms, as all aquatic organisms are adapted to live within a certain range of temperatures. When water temperatures shift outside of the optimal range of aquatic organisms, growth and reproduction rates can be adversely affected. Severe deviations outside of their tolerance range can result in mortality. Salmonids, in particular, require cool water for optimal physiological functioning during various stages of their life cycle, including spawning and rearing. Physical stress and increased susceptibility to fungal infection can occur when temperatures rise above preferred temperatures. Additionally, cold water can hold higher concentrations of dissolved oxygen, and can slow the growth of problem-causing bacteria and algae.

In the LMR&MC watershed, land uses including timber removal, road construction, agricultural practices, and stream-channel disturbances have created conditions that potentially impair water quality by elevating water temperatures. Undesirable effects of these activities, including bank erosion, sedimentation, and removal of riparian vegetation, contribute to increasing water temperatures. Sedimentation and erosion produce wider, shallower stream channels that absorb more solar radiation per unit volume of water than do narrower, deeper channels. A lack of riparian vegetation exacerbates the rate of warming by further increasing the amount of sunlight directly absorbed by the stream (DEQ 2000).

Streams are considered impaired if the rolling seven-day average of the daily maximum temperature exceeds the 64 ^{o}F (17.8 ^{o}C) standard. If stream temperature data are not collected in such a manner that allows calculation of the rolling seven-day average, greater than 25% (and a

Table 8.1. Designated beneficial uses of water bodies in the Molalla River watershed, Oregon.

Beneficial Use
Public Domestic Water Supply
Private Domestic Water Supply
Industrial Water Supply
Irrigation
Livestock Watering
Anadromous Fish Passage
Salmonid Fish Rearing
Salmonid Fish Spawning
Resident Fish and Aquatic Life
Wildlife and Hunting
Fishing
Boating
Water Contact Recreation
Aesthetic Quality
Hydro Power

minimum of at least two exceedences) of the samples must exceed the appropriate standard based on a multi-year monitoring program that collects representative samples during periods of concern. In the LMR&MC watershed, mid- to late-afternoon summer water temperatures are typically of concern (DEQ 1998).

DISSOLVED OXYGEN

Salmonids and other cold-water-adapted aquatic life typically require high concentrations of dissolved oxygen (DO). DO concentrations in streams fluctuate predictably both seasonally and over a 24-hour period. Photosynthesis from aquatic plants, respiration from aquatic organisms, and temperature fluctuations all influence DO concentration changes. During the day, algal photosynthesis can produce high DO concentrations by late afternoon. Then at night, when no photosynthesis occurs, yet respiration by aquatic organisms continues and consumes dissolved oxygen, DO concentrations can significantly decrease by dawn. Decomposition of organic wastes by aquatic microorganisms also consumes oxygen; the amount of oxygen consumed in this process is called the biochemical oxygen demand (BOD).

Dissolved oxygen standards vary with the type of aquatic communities that are supported (cold-, cool-, or warm-water) by a particular water body and whether the water body supports salmon spawning and rearing. Oregon waters identified as supporting cold-water aquatic life are to contain dissolved oxygen concentrations of at least 8 mg/L. During salmonid spawning (October–July), a more restrictive criterion of 11 mg/L (or 95% saturation) is specified. For the purpose of this screening level assessment, the criterion has been set at 8 mg/L, as recommended by the Oregon Watershed Assessment Manual (WPN 1999).

BACTERIA

Bacteria found in the coliform group are used as indicators to determine the sanitary quality of water for drinking water and swimming. These bacteria are relatively harmless microorganisms that can be found in the intestines of humans and warm- and cold-blooded animals. The presence of coliform bacteria suggests the possibility of the presence of more harmful fecal coliform bacteria such as *Escherichia coli*. In the past, fecal coliform data were most commonly collected and standards were based on such measurements. As of 1996, however, the standards were changed to measurements based on the number of *E. coli* colonies (406) per 100 ml as these bacteria are more harmful.

BIOLOGICAL CRITERIA

The biological criteria parameter was established to ensure that the state's waters are of "sufficient quality to support the aquatic species without detrimental changes in the residential biological communities." Streams are listed under this criterion if the aquatic community scores are 60% or less of the reference community condition, as determined by multimetric scores or multivariate model scores (DEQ 1998).

PH

The pH value measures the concentration of hydrogen ions in water. Water of pH 7 is neutral, while pH values below 7 indicate acidic conditions, and pH values above 7 indicate alkaline conditions. The chemical form and availability of nutrients and chemicals are influenced by pH, while metal ions become more toxic at lower pH values (WPN 1999). A range of 6.5 to 8.5 is the pH standard for the Willamette River Basin. If 25% of pH values measured between June and September are greater than pH 8.7, however, DEQ should determine whether higher values are anthropogenic or natural in origin (DEQ, 1998).

NUTRIENTS

The two primary chemical forms that limit plant growth in water are nitrogen and phosphorus. Excess plant and algae growth can occur when these chemicals are loaded into a water body causing areas of low or no dissolved oxygen. In addition, certain algae can produce chemicals that can be toxic to livestock and wildlife. To prevent the growth of problem-causing plants and algae, water quality criteria for total phosphorus and total nitrate have been established. Total phosphorus measures phosphates in the water column and phosphorus in suspended elements, while total nitrate (usually nitrite plus nitrate) measures most of the nitrogen in the water column. Evaluation criteria of 0.30 mg/L for total nitrate and 0.05 mg/L for total phosphorus have been established in areas where TMDLs have not been established, such as in the Molalla River watershed, (WPN 1999).

TURBIDITY

Turbidity, a measure of water clarity, acts as a gauge of the amount of suspended sediment in the water column. Turbidity varies naturally with soil type. Larger, heavier particles, such as sand, will more readily sink to the stream bottom, while smaller, lighter particles such as silts and clays will remain suspended for longer durations. While clear water is aesthetically pleasing, it is also important for aquatic organisms such as salmonids that sight-feed. Additionally, sensitive gill tissues of fish can be damaged by sediment particles in the water column. To evaluate turbidity by the Oregon Water Quality Standards criterion, paired water samples need to be collected. Turbidity data often are not collected in this manner, so an evaluation criterion of 50 NTU (nephelometric turbidity unit) is recommended for the purposes of this screening-level assessment (WPN 1999).

CONTAMINANTS

Contaminants generally fall into two subgroups, metals and organics, both of which can cause toxicity in aquatic organisms. Criteria for metals contaminants are expressed as acute and chronic values. The presence of metals can cause sublethal effects such as physiological stress and reduced growth and reproduction rates (chronic levels) or death (sublethal levels). These regulatory criteria are generally expressed as formulas, as they are based on the hardness of the water. For organic contaminants, any detection recoded above minimum detection levels is an indicator of impaired water quality (WPN 1999).

ANALYSIS OF EXISTING DATA

TEMPERATURE

As part of this assessment, ABR and Molalla RiverWatch deployed Hobo Water Temp Pro water temperature data loggers in the Molalla River and Milk Creek to collect and evaluate summertime water temperature data. Water temperature data collected from the lower Molalla River and lower Milk Creek indicate that summertime water temperatures in 2003 regularly exceeded the state's 64oF temperature standard. Maximum daily temperatures in the mainstem Molalla River above Milk Creek exceeded 64oF on 113 of 125 days (91%) data were collected (Figure 8.1), while daily maximums exceeded 64oF on 90 of 125 days (76%) on lower Milk Creek (Figure 8.2). Maximum daily stream temperatures on upper Milk Creek, although not as high as those on lower Milk Creek and the mainstem Molalla River, still exceeded the 64oF standard on 45 of 125 days between June and October, 2003 (Figure 8.3). Because these data were collected during a drought year, when low flows occurred in the watershed, we recommend collection of additional summertime water temperature data from these water bodies to more thoroughly evaluate water quality.

BACTERIA

Water samples were collected in the mainstem Molalla River by ABR and Molalla RiverWatch in fall 2001 for analysis of *E. coli* concentrations. *E. coli* concentrations ranged from 21.0 to 116.5 colonies/100 mL, all well below the state of Oregon standard of 406 colonies/100 mL. These few data, however, certainly do not suggest that bacterial loading is not an issue in the Molalla River watershed. *E. coli* concentrations are typically correlated with concentrations of suspended sediment (USGS 2003), which become elevated during rainfall events when surface runoff carries sediment particles into streams and rivers. Further sampling for bacteria concentrations is

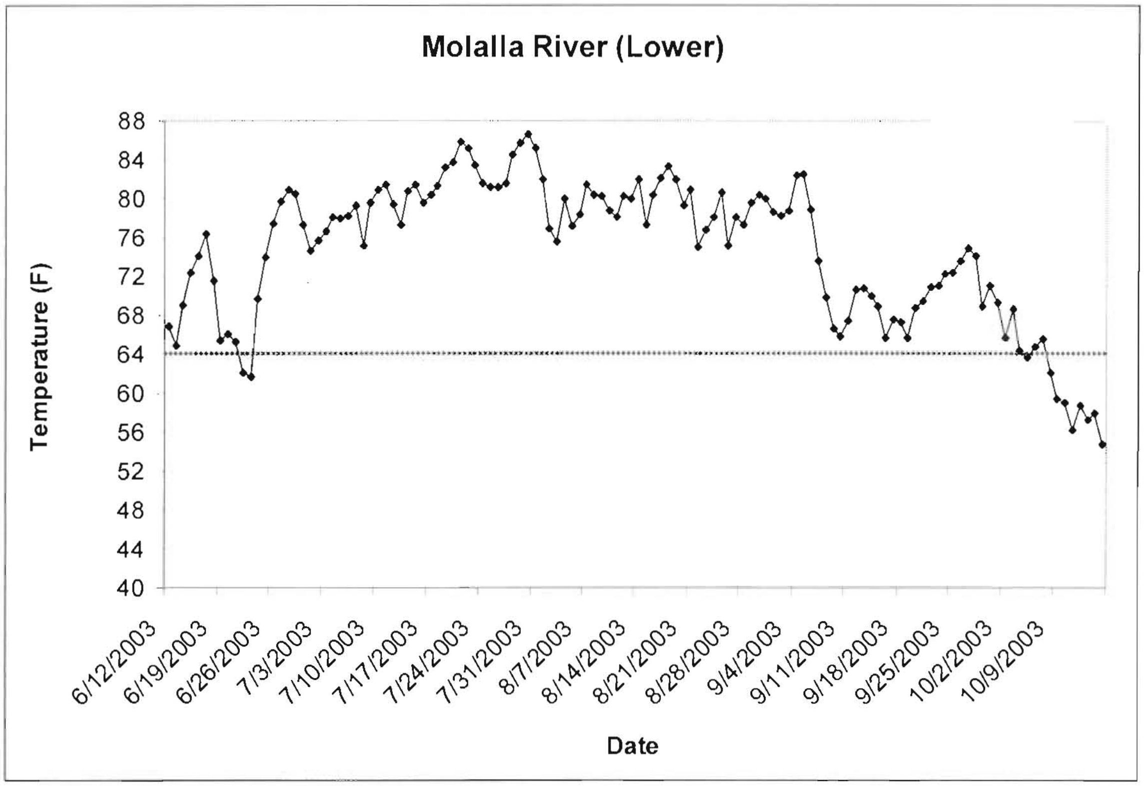

Figure 8.1. Daily maximum water temperatures between June 12 and October 15, 2003 in the Molalla River above the confluence with Milk Creek.

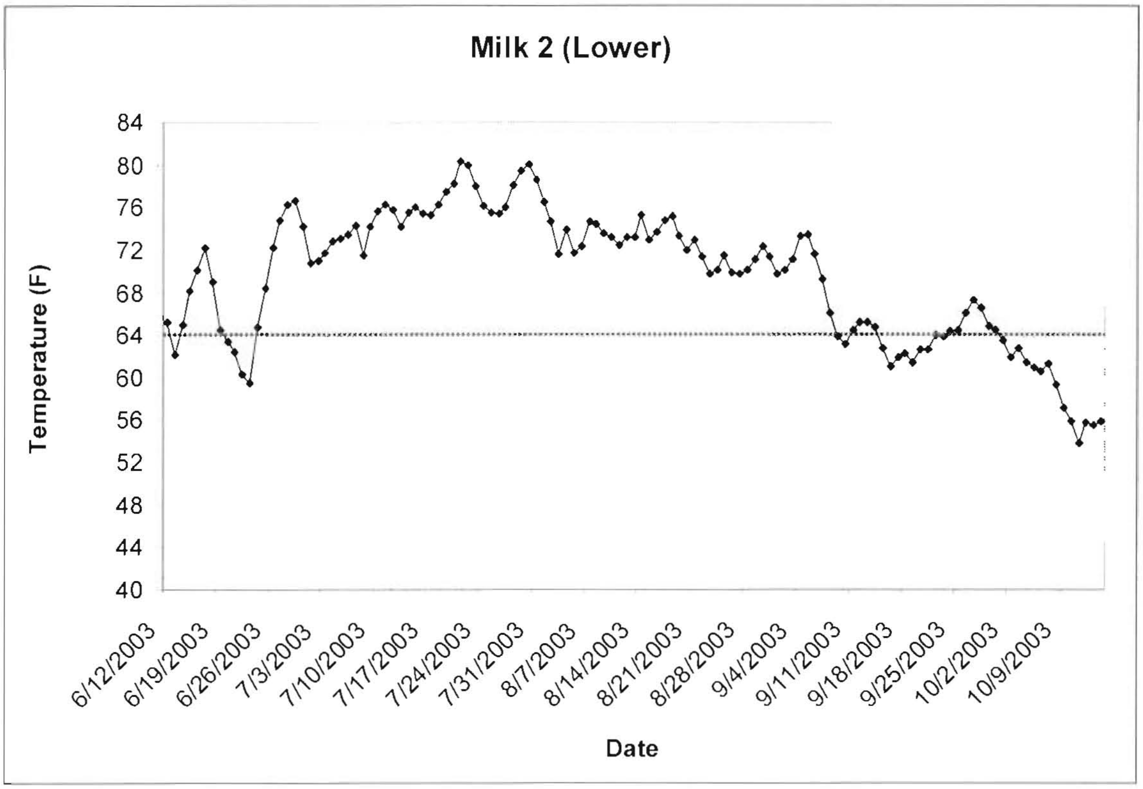

Figure 8.2. Daily maximum water temperatures between June 12 and October 15, 2003 in the lower Milk Creek on the Milk Creek Tree Farm.

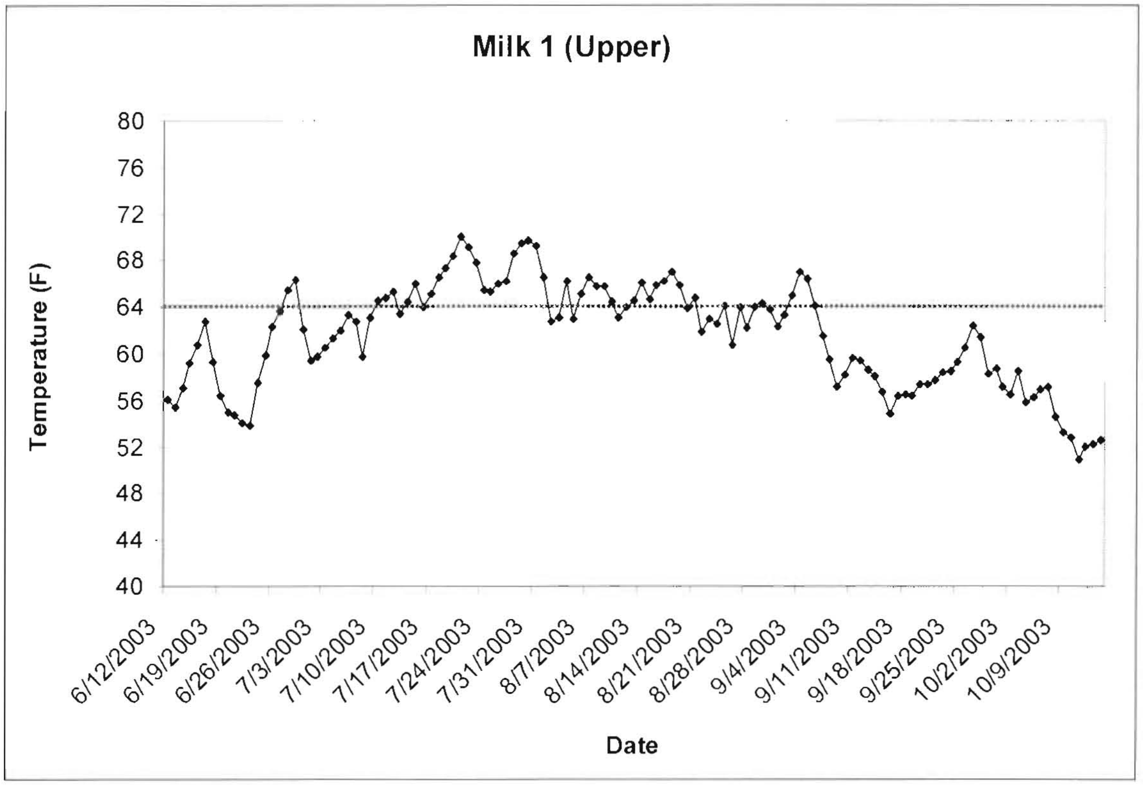

Figure 8.3. Daily maximum water temperatures between June 12 and October 15, 2003 in upper Milk Creek.

warranted under a wider range of flow and turbidity conditions to determine where *E. coli* concentrations exceed state water quality standards throughout the watershed. Bacteria levels in the lower mainstem of the Molalla River are already known to violate state water quality standards.

BIOLOGICAL CRITERIA

The only known sampling in the lower watershed to evaluate biological integrity occurred in 2001 and 2003 by ABR and Molalla River Watch. Through an OWEB grant awarded to RiverWatch in 2001, ABR assessed macroinvertebrate community conditions using DEQ's multimetric index at four locations on the Molalla River within the watershed assessment area (Cole 2002). Biological integrity, based on multimetric scores, ranged from slightly impaired four miles below the confluence with the North Fork of the Molalla River, to severely impaired approximately one mile above the confluence with the Pudding River. Sites located between these two locations scored in the moderately impaired range. The data exhibited a strong trend in increasing biological impairment to benthic communities with increasing distance downriver. These data must be interpreted with caution, however, because the community expected to occur in the Molalla River in the absence of any human disturbance would naturally differ from those of the "reference" conditions because streams used to determine the reference condition would have been considerably smaller than the Molalla River. Rather than being used to determine the present level of impairment of biological communities in the river, we hope the data are used as a baseline against which future data can be compared to determine trends in biological integrity within the river.

NUTRIENTS

DEQ ambient monitoring data collected at the Knights Bridge between 2000 and 2002 indicate that nitrate concentrations sometimes exceed the evaluation criterion used for this assessment of 0.30 mg/L. Total nitrate/nitrite nitrogen concentrations exceeded 0.40 mg/L on 5 of 20 (25% exceedence) sampling episodes during this time period (Figure 8.4). DEQ data indicate that

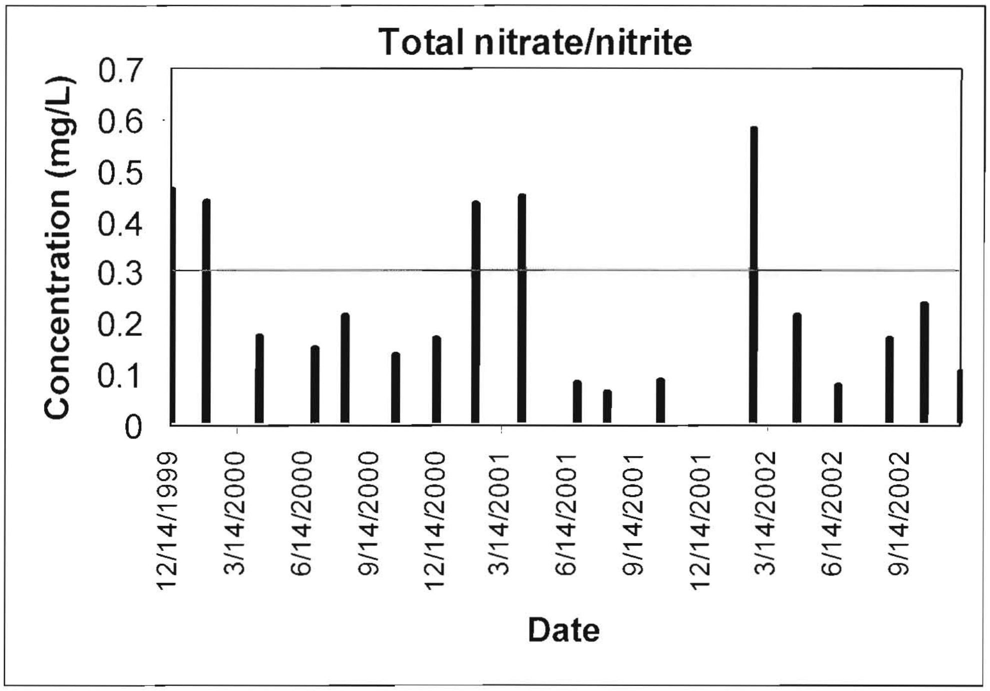

Figure 8.4. Total nitrate/nitrite nitrogen concentrations measured by DEQ from the Molalla River at Knights Bridge between 2000 and 2002. The red line indicates OWEB's evaluation criteria of total nitrate concentrations.

total phosphorus concentrations less frequently exceed the evaluation criterion of 0.05 mg/L.

WATER QUALITY MANAGEMENT PLANNING

Federal law requires that 303(d)-listed waterways be managed to meet state water quality standards. DEQ uses total maximum daily loads (TMDLs), which describe how much of a particular pollutant a water body can receive without violating water quality criteria (DEQ, 2001), to reduce pollution of listed waters. TMDLs are calculated for each pollutant entering a body of water, and then these maximum allowable pollutant loads are allocated among the various point sources and categories on nonpoint sources within the subbasin. TMDLs for 303(d) listed waters occurring in the LMR&MC watershed are scheduled for completion by DEQ in 2007 (DEQ, 2003). These TMDLs will allocate pollutant loads to different sources such as agriculture, urban areas, and federal lands.

Once each TMDL is set, the Designated Management Agency for each category of contributing sources is required to develop a Water Quality Management Plan (WQMP) to achieve TMDL load allocations. These plans describe what actions will be taken to achieve desirable pollutant loads. The Oregon Departments of Forestry (ODF) and Agriculture (ODA), through Memoranda of Understanding with DEQ, serve as the Designated Management Agencies for forestry and agricultural activities on state and private lands. The BLM and the US Forest Service serve as the Designated Management Agencies on federally administered lands (DEQ 2000).

In advance of TMDL completion for the Molalla River watershed, the Molalla-Pudding-French Prairie-North Santiam Subbasins Local Advisory Committee, with assistance from the Oregon Department of Agriculture and the Marion Soil and Water Conservation District, has developed an agricultural Water Quality Area Management Plan. The mission of the plan is to "promote agricultural management practices that protect and improve water quality in the Molalla River, Pudding River, North Santiam River, Santiam River, Mill Creek, and French Prairie Area subbasins while maintaining agricultural viability" (LAC 2002). The plan focuses on education and incentives to promote voluntary efforts to protect and improve water quality as affected by agricultural practices. This plan and the administrative rules will become part of the Management Area strategy to address TMDLs. The plan, in combination with other water quality management plans for the area, will represent the State's plan to meet achieve TMDLs in the Molalla River watershed (LAC 2002).

303(D)-LISTED WATERS

Two river or stream segments in the LMR&MC watershed are currently listed as water quality limited water bodies (Figure 8.5; DEQ 2003). Both of these segments occur on the mainstem Molalla River (Table 8.2). The mainstem Molalla River from RM 0 to RM 25 is listed for water temperature, flow modification, and fecal coliform water standard violations. In this river segment, DEQ data from site 4022029 showed a standard exceedence rate of 89% (32 of 36) with exceedences occurring each monitoring year between water years (WY) 1986 and 1990. In this same segment, DEQ data from sites 4022029 and 402314 showed 21% and 11% exceedence rates for the fecal coliform standard, with maximum values of 1100 at each site between WY 1986 and 1995. BLM data collected between 1993 and 1996 from the Molalla River below the Table Rock Fork and above the North Fork warranted listing of this segment for violating the 64°F salmonid rearing water temperature standard.

WATER QUALITY MONITORING EFFORTS

AMBIENT WATER QUALITY MONITORING NETWORK

DEQ currently monitors 156 sites across the state to provide water quality data for trending, standards compliance, and problem identification (DEQ 2000). Generally, sites occurring on larger river sections in lower portions of watersheds, known as integrator sites, are selected because these areas best reflect the integrated effects of various types and sources of pollution (DEQ 2000). Data collected from these sites are analyzed, in part, with the Oregon Water Quality Index a set

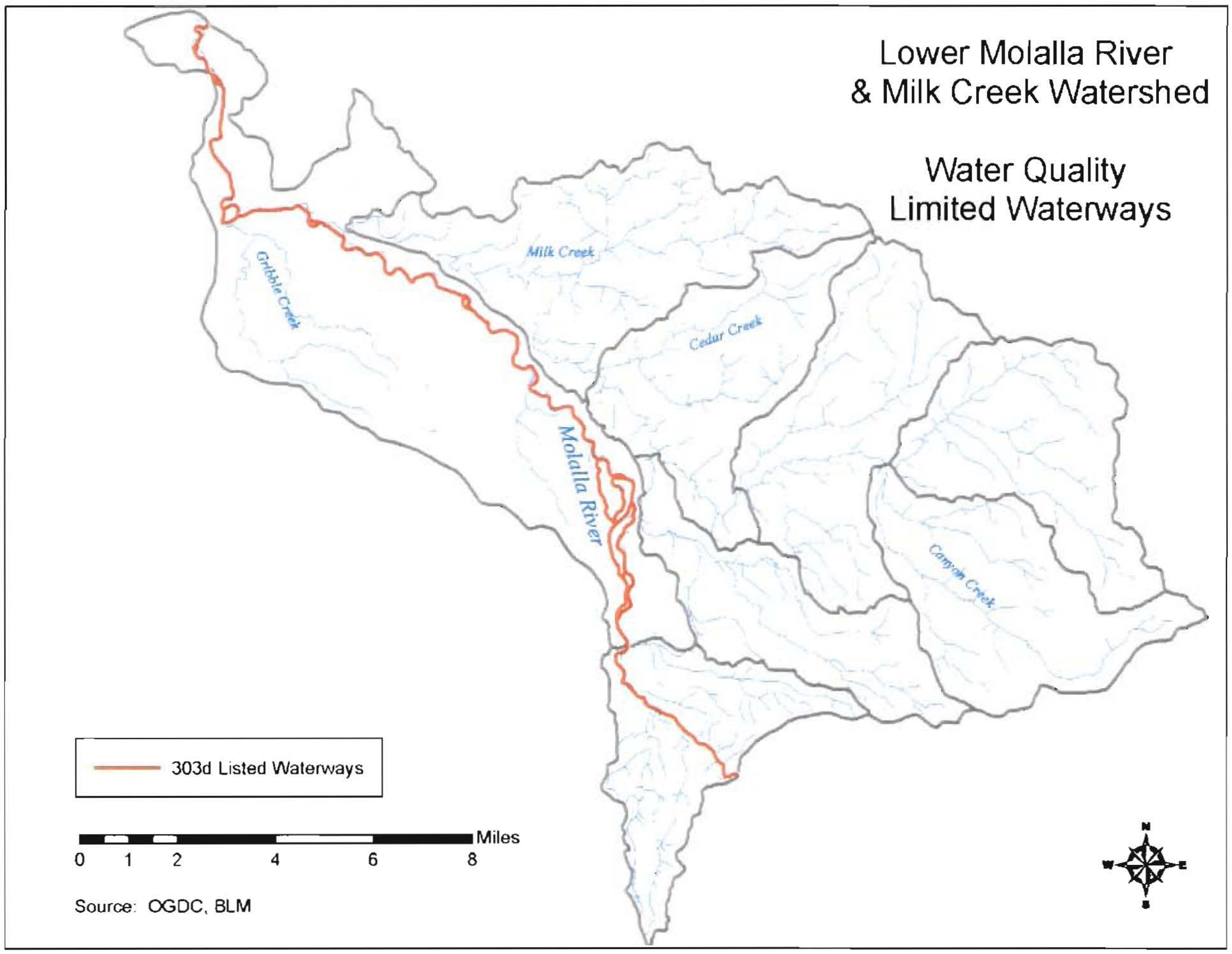

Figure 8.5. 303(d)-listed waterbodies occurring in the lower Molalla River & Milk Creek watershed (source: DEQ).

Table 8.2. Water-quality-limited water bodies occurring in the lower Molalla River & Milk Creek watershed.

Water Body	Segment (RM)	Parameter	Criteria	Season	Year Listed
Molalla R.	0 to 25	Fecal Coliform	Geometric Mean of 200, No more than 10%>400	Winter/ Spring/Fall	1998
Molalla R.	0 to 25	Temperature	Rearing: 17.8 C	Summer	1998
Molalla R.	0 to 25	Flow Modification	The creation of tastes or odors or toxic or other conditions...		2002
Molalla R.	25 to 38.1	Temperature	Rearing: 17.8 C	Summer	1998

of eight water quality parameters to produce a score describing the overall water quality at a site. The water quality parameters include temperature, dissolved oxygen, biochemical oxygen demand, pH, total solids, ammonia and nitrate nitrogens, total phosphorus, and fecal coliform. Scores range from 10 (worst) to 100 (highest). Sites scoring less than 60 are classified as having very poor water quality, 60–79 as poor, 80–84 as fair, 85–89 as good, and 90–100 as excellent (DEQ 2000).

The Molalla River at Knights Bridge in Canby (site 402314, RM 2.5) has been monitored under this program since 1985. Currently, water quality data are collected from this site approximately bimonthly. Water temperature and fecal coliform data collected from this site have been used to place the lower Molalla River on the 303(d) list for standards violations of these parameters. The Molalla River at Knights Bridge is currently classified as having good and significantly increasing water quality, based on average summer and fall/winter/spring OWQI scores of 88 and 88 from 1989–1998 data (DEQ 2000).

The Oregon Water Quality Index Report for water years 1986–1995 summarized the water quality of the lower Molalla River as being better than that of the Pudding River, and attributed this to the absence of major point sources and the presence of more favorable hydrologic conditions which enables the Molalla River to more readily assimilate pollution (Cude 1996). The report adds that elevated levels of total phosphates, nitrate and ammonia nitrogen, fecal coliform, and biochemical oxygen demand occur in the fall, winter, and spring in Molalla River at Canby. High temperatures, high biochemical oxygen demand, and low dissolved oxygen concentrations also occur during low flow summer months and are attributable to non-point source pollution from agricultural areas in the lower watershed. The report concludes that these impacts have increased over time, as water quality had significantly declined during the reporting period of 1985–1995 (Figure 8.6).

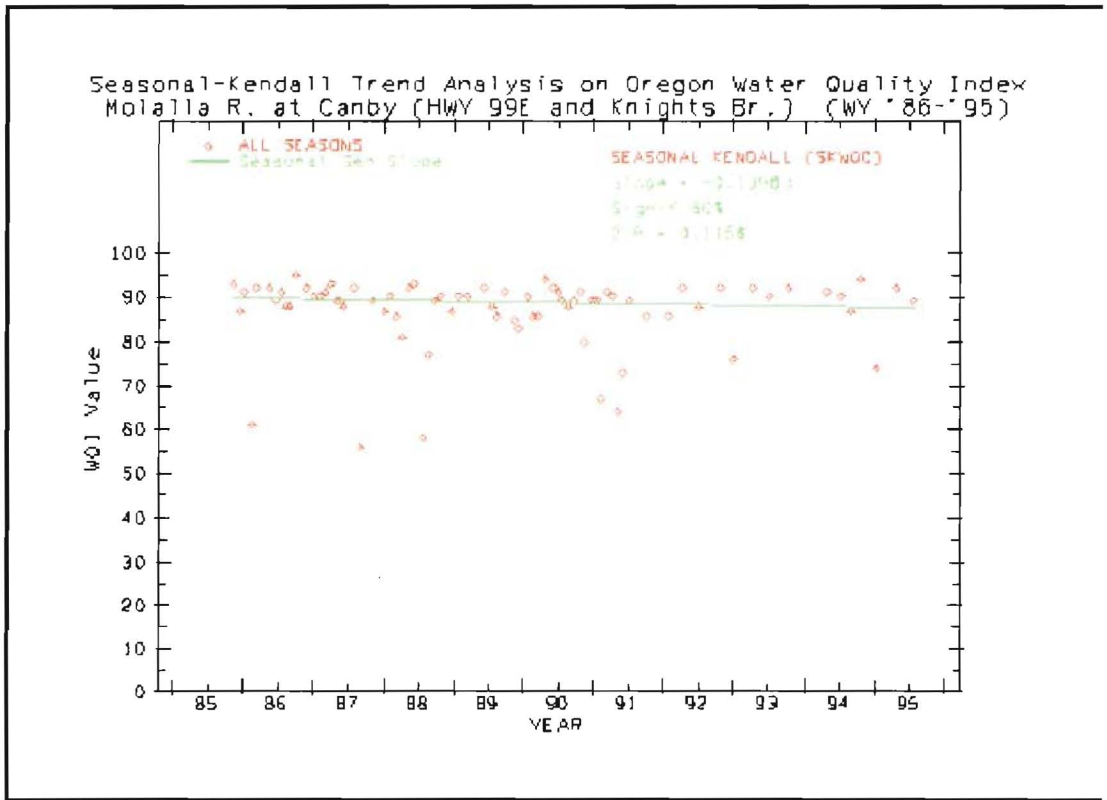

Figure 8.6. Oregon Water Quality Index scores from the Molalla River and Knights Bridge in Canby, 1986–1995. Source: Cude 1996 (http://www.deq.state.or.us/lab/wqm/wqi/midwill/midwill3.htm)

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CHAPTER NINE: FISH AND FISH HABITAT

INTRODUCTION

The Molalla River watershed, owing to its wide range of aquatic habitats, supports a diverse assemblage of fish species, including numerous species of both native and introduced origins (Table 9.1). Fish populations and fish communities have been altered by changes to physical, chemical, and biological components of streams and rivers through land use practices and introductions of non-native fish species and stocks. In this chapter, the current conditions of fish populations are examined, with an emphasis on native salmon and trout species, using existing reports, fish distribution and abundance data, and other technical information. Because salmonids (salmon and trout) are regarded as among the most sensitive aquatic species, information pertaining to their abundance and distribution can help identify what portions of a watershed are most degraded with respect to their ability to support salmonids and can help identify trends in watershed conditions over time. Fish habitat quality in the LMR&MC watershed has been degraded by a combination of forestry practices, agricultural practices, roads and road crossings, and residential and industrial development. Salmonid production in the watershed is limited by combined effects of water quality and quantity, and physical habitat degradation.

FISH SPECIES

WINTER STEELHEAD

Origin

Winter steelhead are native to the Molalla River watershed and occur throughout the watershed, using the upper reaches most extensively (Wevers et al. 1992). The Molalla River winter steelhead population belongs to the coastal steelhead subspecies, *Onchorhynchus mykiss irideus*, that occurs in coastal river basins from California to Alaska (Kostow 1995). This subspecies includes both resident (rainbow trout) and anadromous phenotypes, both of which occur in the Molalla River watershed. Two winter-run steelhead stocks have recently occurred in the watershed; the native late-run stock is naturally produced, while the Big Creek early-run stock was introduced in 1970 (Wevers et al. 1992). This particular stock of fish originated in Big Creek, a tributary to the lower Columbia River.

Life History

Across its range, the coastal steelhead expresses a range of life histories including various freshwater and saltwater rearing strategies and several adult spawning migration strategies (Kostow 1995). Juvenile steelhead may rear for one to four years in freshwater before migrating to the ocean. Saltwater residency, in turn, may last one to three years before adults return to freshwater to spawn (Kostow 1995). In the Molalla River watershed, most native late-run winter steelhead enter the river between mid-February and early May, with peak numbers occurring between late March and early April (Wevers et al. 1992). The early-run stock of Big Creek steelhead enter the Molalla from about late November through late February.

Spawning by native late-run fish in the Molalla watershed occurs from early April to late May, whereas early-run Big Creek fish are thought to reach peak spawning activity by late February (Wevers et al. 1992). Emergence occurs in early summer. Most (88%) naturally-produced winter steelhead rear in streams within the watershed for two years, at which point smoltification occurs to allow emigration from freshwater rearing areas to saltwater. Approximately 62% of the naturally produced steelhead return to the Molalla to spawn after spending two years in the ocean (2-salt fish), while approximately 35% return after three years (Wevers et al 1992).

Listing and Population Status

Molalla River winter steelhead belong to the Upper Willamette River Steelhead Evolutionarily Significant Unit (ESU). This ESU includes all naturally spawned populations of winter-run steelhead in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River, inclusive. This ESU was listed as threatened by the National Marine Fisheries Service (NMFS) on March 25, 1999. The listing includes only naturally-produced fish and excludes hatchery-produced fish. The Molalla River watershed is one of only three river systems above the Willamette Falls supporting native steelhead

Table 9.1. Fish Species in the Lower Molalla River & Milk Creek watershed

Species/Stock	**Scientific Name**	**Native/ Introduced**	**Present Status**	**Source**
Winter Steelhead	*Onchorhynchus mykiss*	Native – supplemented	Present, **ESA listing status T**	Wevers 1992
Summer Steelhead	*Onchorhynchus mykiss*	Introduced 1984	Stocking discontinued 1999 – no longer present?	Wevers 1992
Spring Chinook	*Oncorhynchus tshawytscha*	Native - supplemented	Present, **ESA listing status T**	Wevers 1992
Fall Chinook	*Oncorhynchus tshawytscha*	Introduced 1967	Stocking discontinued	Wevers 1992
Coho salmon	*Oncorhynchus kisutch*	Introduced 1920	Stocking discontinued 1988	Wevers 1992
Rainbow Trout	*Onchorhynchus mykiss*	Native	Stocking discontinued 1999	Wevers 1992
Cutthroat Trout	*Oncorhynchus clarki*	Native	Present	Wevers 1992
Mountain Whitefish	*Prosopium williamsoni*	Native		Wevers 1992
Pacific Lamprey	*Lampreta tridentata*	Native	?	Kostow 2002
Western Brook Lamprey	*Lampreta richardsoni*	Native	?	Kostow 2002
Largemouth Bass	*Micropterus salmoides*	Introduced	?	Wevers 1992
Black Crappie	*Pomoxis nigromaculatus*	Introduced	?	Wevers 1992
White Crappie	*Pomoxis annularis*	Introduced	?	Wevers 1992
Bluegill	*Lepomis macrochirus*	Introduced	?	Wevers 1992
Pumpkinseed	*Lepomis gibbosus*	Introduced	?	Wevers 1992
Warmouth	*Lepomis gulosus*	Introduced	?	Wevers 1992
Green Sunfish	*Lepomis cyanellus*	Introduced	?	Wevers 1992
Yellow Perch	*Perca flavescens*	Introduced	?	Wevers 1992
Sand Roller	*Percopsis transmontana*	Native	Present	Wevers 1992
Redside shiner	*Richardsonius balteatus*	Native	?	
Speckled dace	*Rhinichthys osculus*	Native	?	
Longnose dace	*Rhinichthys cataractae*	Native	?	

belonging to this ESU that have not yet been severely affected by hydropower development (Wevers et al 1992).

Native late-run winter steelhead presently occur in the Molalla River watershed. Within the LMR&MC watershed, adult spawning occurs in the Molalla River above the City of Molalla, in Milk Creek above the confluence with Nate Creek, and in Canyon Creek, a major tributary to Milk Creek (Figure 9.1). Present efforts to monitor abundance and estimate population sizes include redd counts performed on index streams in May and late-run fish counts at the Willamette Falls. Redd counts are performed between May 1 and May 31 on index streams in the watershed. Because most steelhead use occurs in the upper watershed (i.e. outside the assessment area), most surveys, other than those occurring on Milk Creek occur outside the geographic area covered in this assessment. Redd counts performed between 1980 and 2000 on index streams within entire the Molalla River watershed indicate that steelhead abundance was generally declining through the 1980s and into the mid 1990s, and has since generally increased (Figure 9.2). Again, these counts primarily represent steelhead use of the upper Molalla River watershed, above the Glen Avon Bridge and outside the assessment area.

Steelhead run size estimates for the Molalla River watershed are made by apportioning the Willamette Falls late-run count among the Molalla, N. Santiam, S. Santiam, and Calapooia rivers based the relative number of redds counted each year in each watershed (calculated as redds/mi x number of miles of spawning habitat). Data from 1980 through 1997 indicate a general trend of decreasing

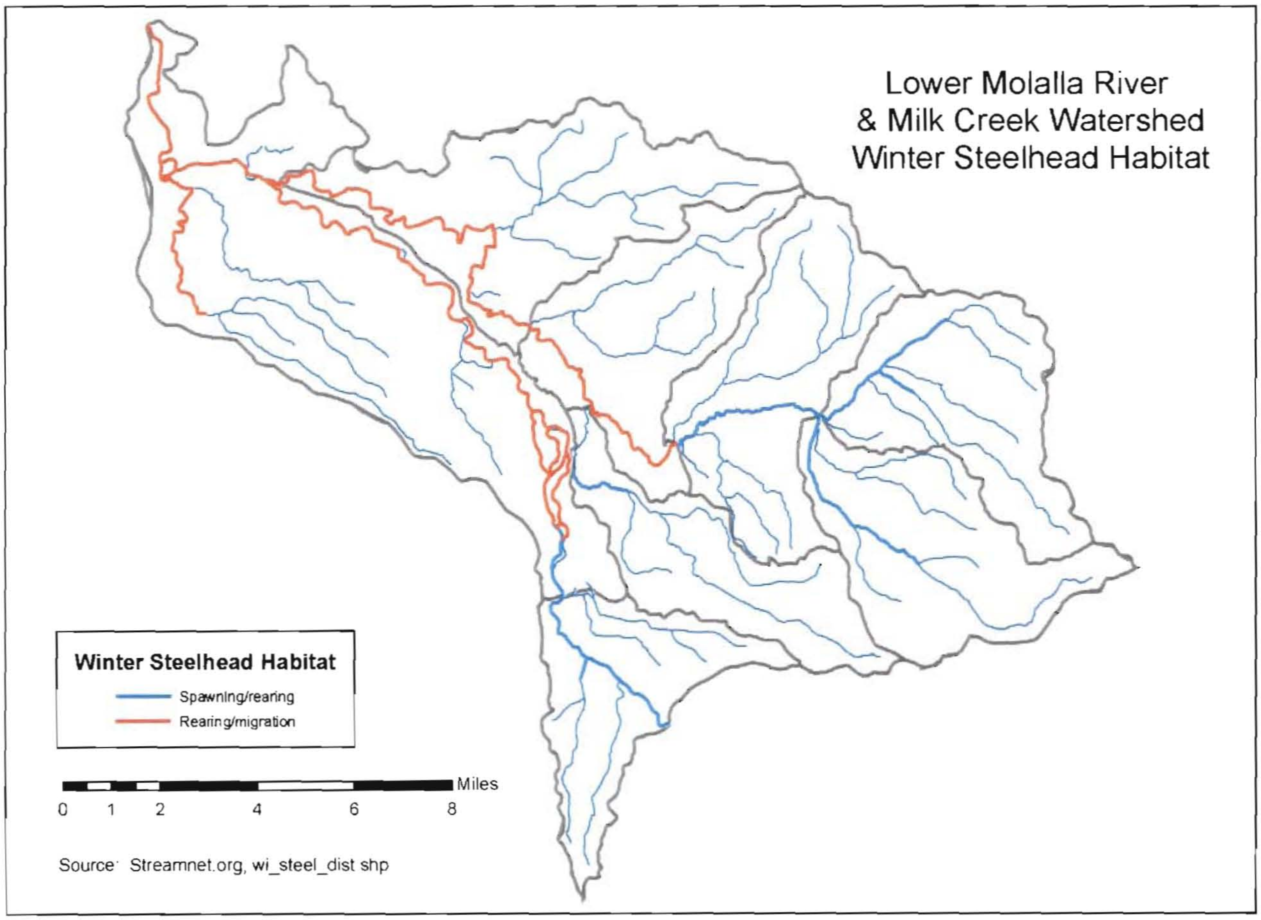


Figure 9.1. Winter steelhead distribution in the lower Molalla River & Milk Creek watershed. (Source: Streamnet 2003, from 2001 ODFW Subbasin Planning)

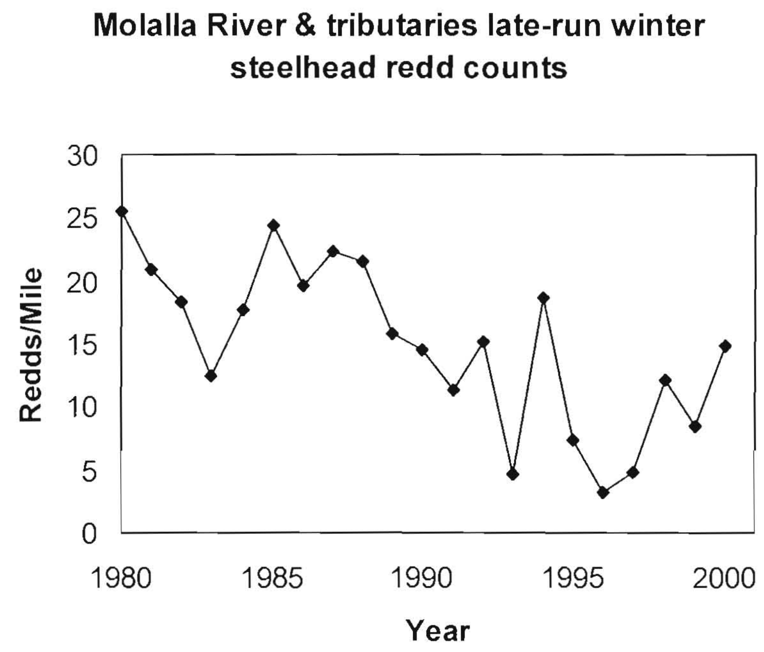


Figure 9.2. Molalla River & Tributaries late-run winter steelhead redd counts, 1980–2000.

numbers of returning late-run winter steelhead adults to the Molalla River watershed (Figure 9.3).

Management and hatcheries

Winter steelhead in the Molalla River are not currently supplemented with hatchery fish. Historically, several stocks of winter steelhead have been introduced to the Molalla River watershed. No hatcheries exist in the Molalla or Pudding River watersheds. The early-run Big Creek stock was first introduced to the Molalla in 1970 with the introduction of 30,000 yearling smolts. That same year, 30,000 Alsea stock winter steelhead smolts were also stocked (Wevers et al. 1992). Alsea stock steelhead plantings were discontinued in 1974, however Big Creek stock plantings continued through the 1990s. Stocking of Big Creek early-run winter steelhead, intended to extend the winter steelhead fishery by providing an early-run fish (Wevers et al. 1992), was terminated in 1997 (NMFS 2000) amidst concerns over competition and hybridization with the native stock and to ensure compliance with ODFW's Natural Production and Wild Fish Management Policy (BLM & USFS 1999). Although natural production of Big Creek stock is thought to occur it is not known how much the Big Creek stock has contributed to natural production in the watershed (Wevers et al. 1992).

SUMMER STEELHEAD

Summer steelhead are not native to the Molalla River watershed and are no longer planted in the river. Skamania stock smolts were first introduced into the Molalla River in 1984 to increase angling opportunities for steelhead from a four-month winter season to almost year-round. Releases of summer steelhead into the Molalla were restricted to the lower reaches of the mainstem (between RM 21 and 35) to avoid potential negative effects on the native winter steelhead (Wevers et al. 1992). Releases of hatchery summer into the Molalla River watershed were terminated in 1999 (NMFS 2000). Natural production by summer steelhead was unknown, but was thought to be minimal (Wevers et al. 1992).

Summer steelhead entered the Molalla River from early March through late September with peak entry occurring between mid-June and early

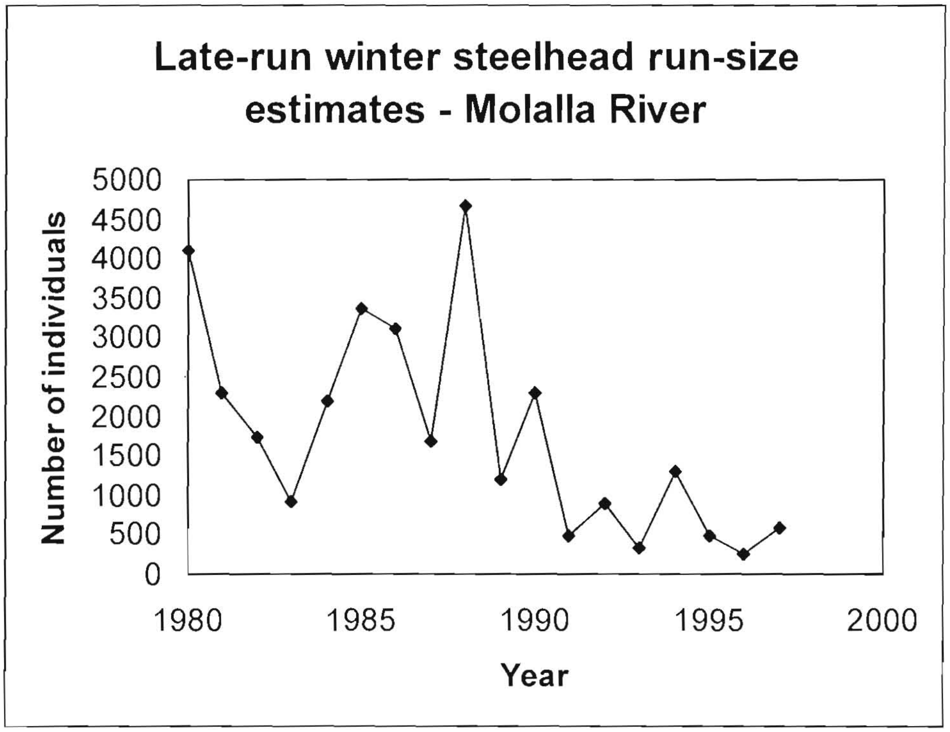


Figure 9.3. Estimates of late-run winter steelhead returning to Molalla River watershed, 1980–1997 (ODFW data).

July (Wevers et al. 1992). Molalla River summer steelhead run sizes averaged 3,778 fish between 1986 and 1990. Most fish were returning to the river after spending two years in salt water (Wevers et al. 1992). All scales collected from summer steelhead caught in the Molalla River from June through October 1990 (n = 78) showed patterns consistent with hatchery rearing, indicating little, if any natural reproduction of the summer stock occurred at that time in the watershed (Wevers et al. 1992).

SPRING CHINOOK SALMON

Origin

Spring chinook salmon were native to the Molalla River watershed. The original run is thought to be extinct from the watershed (BLM & USFS 1999). Current runs of chinook salmon into the Molalla River watershed are thought to consist largely or entirely of fish of hatchery origin.

Life History

Oregon chinook salmon populations exhibit a wide range of life history patterns, more so than do coho or chum salmon. Molalla River spring chinook salmon enter the Molalla River between mid-April and late June. Spawning occurs between late September and late October (Wevers et al. 1992). It is not known whether any natural production occurs in the Molalla River watershed. Generally, Columbia River spring chinook reside in freshwater for one summer and one winter before emigration to the ocean occurs (Kostow 1995). Juveniles of this life history type of prolonged residence and rearing in freshwater typically move downstream into large rivers during their first spring, then migrate to the ocean during their second spring (Kostow 1995).

Listing Status/ Population Trends and Status

Molalla River spring chinook belong to the Upper Willamette River Spring Chinook Evolutionarily Significant Unit (ESU). This ESU includes all naturally spawned populations of spring chinook salmon in the Clackamas River and in the Willamette River, and its tributaries, above Willamette Falls, Oregon. This ESU was listed as threatened by the National Marine Fisheries

Service (NMFS) on March 24, 1999. The listing includes only naturally-produced fish and excludes hatchery-produced fish.

Currently, insufficient information exists to determine whether a natural population occurs in the Molalla River watershed (ODFW 2001). Estimates of abundance have been assessed primarily through snorkel surveys of the mainstem of the Molalla River to estimate run sizes. Snorkel surveys conducted between 1961 and 1989 indicated a steady decline in returning adults from the early 1960s through the mid 1970s (Figure 9.4). Adult returns averaged 12 per mile in the 1960s, dropping to 5 per mile in the early 1970s. By 1975, counts were lower than 0.5 spring chinook per mile. Counts again increased through the 1980s, and were likely attributable to the hatchery program initiated in 1981 (Wevers et al. 1992). High prespawning mortality occurs in the Molalla (SSPP 1990). Likely contributing factors are incidental harassment and illegal harvest from improved access to critical holding areas, low flows which crowd fish and limit spawning habitat, and high summer temperatures which can reduce fish condition and increase susceptibility to disease (ODFW 1990). Historically, spring chinook use occurred throughout much of the lower watershed (Figure 9.5).

Management and hatcheries

In response to the precipitous decline in returning spring chinook to the Molalla River through the 1970s, Willamette stock spring chinook pre-smolts, smolts, and adults have been planted in the Molalla River. Stocking was initiated in 1981 with the release of 83,445 smolts into the Molalla (Wevers et al. 1992). Through the 1980s and 1990s releases of various life stages have occurred almost annually. Currently, spring chinook released into the Molalla River are from broodstock collected at the S. Santiam Hatchery. Fish are reared from early egg stage to their time of release at the Willamette hatchery (ODFW 2001).

The Oregon Wild Fish Management Policy (since superceded by the Oregon Native Fish

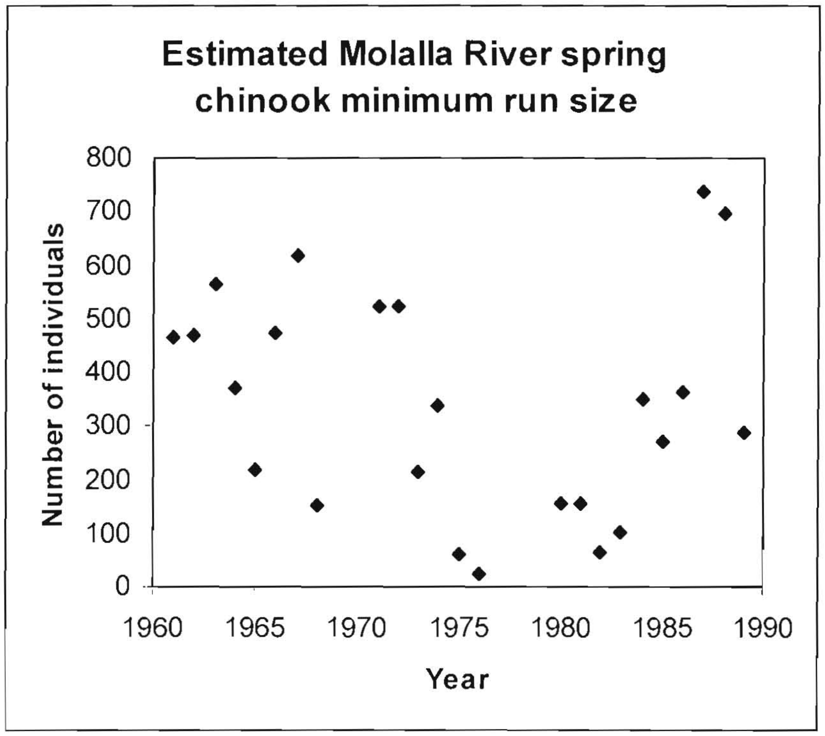
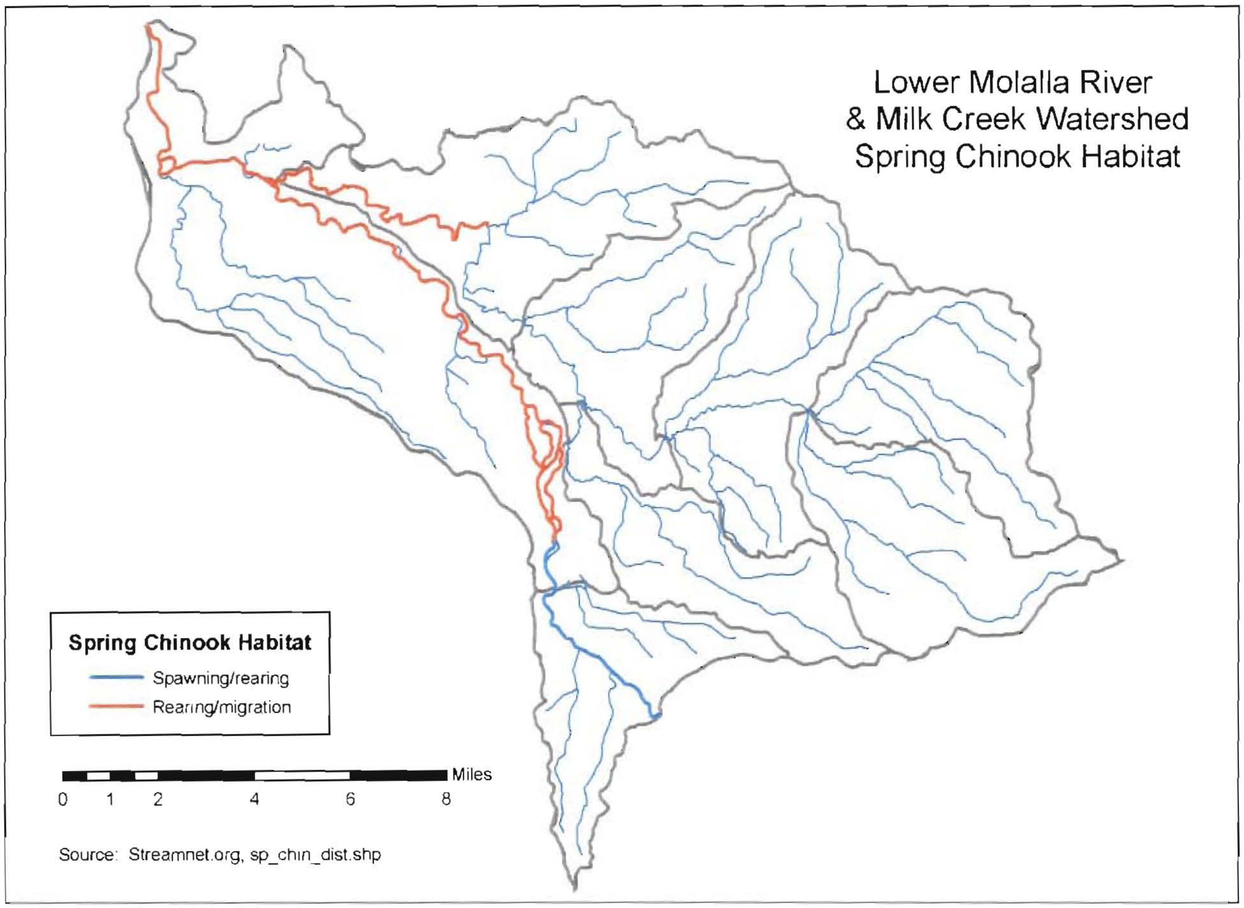


Figure 9.4. Estimates of spring chinook salmon returning to Molalla River watershed, 1961–1989 (ODFW data).


Lower Molalla River & Milk Creek Watershed Spring Chinook Habitat

Source: Streamnet.org, sp_chin_dist.shp

Figure 9.5. Spring chinook salmon distribution in the lower Molalla River & Milk Creek watershed. (Source: Streamnet 2003, from 2001 ODFW Subbasin Planning)

Conservation Policy) was adopted to reduce the adverse impacts of hatchery programs on wild native stocks (ODFW 1992). This program required information on the relative abundance of hatchery and wild fish in spawning populations. In response to this need, all hatchery spring chinook salmon in the Willamette basin, beginning with the 1997 brood, were marked with adipose fin clips (Schroeder et al. 2002). Chinook spawning surveys in the upper Molalla River watershed in 2002 counted 102 chinook carcasses, only 7 of which had no fin clips (Schroeder et al. 2002), indicating that most, if not all of the chinook returning to the Molalla River are hatchery fish. Not all hatchery fish are marked with adipose fin clips; for example, about 3% of fish from 76 release groups in the 1996-1999 broods were released without fin clips. Therefore, fish without fin clips must be examined for thermal marking of their otoliths to determine whether they are of hatchery origin or stream-bred. Only two of the seven carcasses recovered without fin clips in 2002 lacked thermally marked otoliths, indicating that approximately 2% of the returning adults to the Molalla in 2002 were stream-bred fish (K, Shroeder 2003, personal communication). ODFW plans to continue spawning surveys in the Molalla River to estimate the relative abundance of hatchery and wild fish, and will also perform spring juvenile surveys to determine the abundance of stream-bred juvenile chinook salmon in the Molalla River watershed (K. Schroeder 2003, personal communication).

FALL CHINOOK SALMON

Fall chinook are not native to the Molalla River watershed, but were planted in the watershed between 1967 and 1992. The run did not support any sport fishery, but was managed to contribute to ocean and Columbia River fisheries and therefore reduce harvest of less abundant or more important Oregon chinook salmon stocks (Wevers et al. 1992). Unlike spring chinook salmon, fall chinook juveniles spend only a few months rearing in fresh water before they emigrate in spring or early summer (Wever et al. 1992). Accordingly, fall chinook are better able to make use of marginal habitat in the lower Molalla River that limits successful rearing by spring chinook, steelhead, and trout that would use this habitat through the warmer late summer and fall months. Fall chinook occur only in the lower Molalla River, as 95% percent of fish spawn below river mile 18.6 (Wevers et al. 1992). Stocking records through 1988 indicate that Tule stock fall chinook were planted in the Molalla annually (Wevers et al. 1988). Stocking has since been discontinued. It is not known to what extent, if any, fall fun chinook salmon continue to enter the Molalla River.

COHO SALMON

Coho salmon are not native to the Willamette River basin above Willamette Falls, but were introduced above the falls in the 1920s (Wevers et al. 1992). Coho salmon were stocked in the Molalla River from the 1950s to 1970s in an effort to establish a naturally-produced run of coho in the upper Willamette Basin. Stocking under this program was terminated when returns did not produce expected numbers of fish. However, coho plantings continued in the Molalla through the 1980s in an effort to improve ocean and Columbia River fisheries (Wevers et al. 1992). Wevers et al (1992) reported that coho plantings in the Molalla River were discontinued in 1988 and suggested that runs produced by the hatchery program would fall below self-sustaining levels within 3-4 years following the termination of stocking.

RAINBOW TROUT

Rainbow trout, the resident phenotype of the *Onchorhynchus mykiss irideus* subspecies, is thought to be native to the Molalla River watershed. However, resident rainbow trout in the watershed may also be the progeny of steelhead or stocked rainbow trout (Wevers et al. 1992). Because resident rainbow trout are very difficult to distinguish from juvenile steelhead, rainbow trout distribution in the watershed in unknown (Wevers et al. 1992). Isolated populations of resident rainbow trout occur in several tributaries in the upper watershed, but none are known to occur in the lower watershed within the geographic scope of this assessment. No population estimates currently exist of rainbow trout in the LMR&MC watershed.

Catchable rainbow trout were stocked in the Molalla River watershed from the 1920s until 1999 to provide a sport fishery. Releases averaged almost 12,000 fish per year through the 1980s. Catch surveys performed in the mid 1980s indicated that most trout caught in the mid reaches of the Molalla River (RM 27 to RM 38.5) were planted rainbow trout, with few native cutthroat, rainbow, or steelhead juveniles harvested (Haxton 1985), suggesting that the middle and lower Molalla River does not provide suitable year-round habitat for resident trout and juvenile salmon. Wevers et al. (1992) suggest that warm water temperatures and competition with steelhead likely limit production of resident rainbow trout in portions the Molalla River watershed.

CUTTHROAT TROUT

Coastal cutthroat trout, *Onchorhynchus clarki clarki,* are native to the Molalla River watershed. Cutthroat trout occur in the upper mainstem Molalla and tributaries throughout the upper watershed. Despite numerous surveys to determine the distribution and estimate population sizes of resident trout in the upper watershed, information describing cutthroat trout distribution and population sizes in the LMR& MC watershed is scarce. ODFW fish presence surveys performed in the 1980s documented cutthroat trout use of Bittner Creek (unpublished ODFW data). Hatchery releases of cutthroat trout have never been made in the Molalla River watershed (Wevers et al. 1992).

OTHER SPECIES

Mountain whitefish

Mountain whitefish, *Prosopium williamsoni*, the only whitefish native to Oregon, occur in larger rivers and streams in the Willamette River basin, including the Molalla River. Mountain whitefish typically spawn in the fall in gravel substrates of stream riffles and also prefer to use riffle habitats in streams during summer months (Kostow 1995). In the Molalla River watershed, mountain whitefish occur throughout the mainstem up to river mile 47, as well as the North Fork and Table rock Forks in the upper watershed (Wevers et al. 1992). Snorkel surveys conducted in 1973 produced density estimates of 14.7 fish per 100 feet of the Molalla River between RM 0 and 47 (Wevers et al. 1992).

Lamprey *spp.*

Lampreys are primitive anadromous fish that reside in freshwater for years as larvae. Both the Pacific Lamprey (*Lampreta tridentata*) and the western brook lamprey (*L. richardsoni*) are thought to occur in the Molalla River watershed. Kostow (2002) writes that "(i)ncidental observations suggest that lampreys are still well distributed through the Willamette Coast Range subbasins, the Molalla/Pudding system, in the lower Santiam, and in the Calapooia. Pacific lamprey are widespread in coastal and Columbia River drainages in Oregon, but its distribution and abundance in particular watersheds is poorly known due to lack of surveys and studies (Kostow 1995). Pacific lamprey were designated as "sensitive-vulnerable" by the Oregon Department of Fish and Wildlife in 1993.

Warmwater Game Fish

There is no documentation for the initial introduction of warmwater gamefish to the Molalla Subbasin (Wevers et al. 1992). The first populations were likely established by migration of fish from the Willamette River (Wevers et al. 1992). Warmwater fish known to occur in the Molalla include largemouth bass, brown bullheads, bluegill, warmouth, yellow perch, green sunfish, pumpkinseed, and both black and white crappie (Wevers et al. 1992). Channel catfish have been released into the Pudding subbasin (Wevers et al. 1992), and may have migrated down into the Molalla River. Populations of some warmwater fish may be sizable because of warm, low flows in the lower reaches during the summer (Wevers et al. 1992). Smallmouth bass occur in the lower reaches but to what extent they extend up stream is unknown (Adam caught one). Species composition and distribution is unknown (Wevers et al. 1992).

Sand Roller

Sand rollers are a trout-perch native to the Willamette system (Wevers et al. 1992). Sand rollers have been collected from Gribble Creek in the LMR&MC watershed, but their distribution or abundance through the watershed is poorly understood. Wevers et al. (1992) indicated that sand rollers may be sensitive to habitat degradation and water diversions occurring in the lower Molalla River watershed and suggested that determining its status in the Molalla/Pudding subbasin should be a high priority as part of the subbasin's fish management planning.

Sand rollers prefer the lower gradient reaches of rivers and streams (Wevers et al. 1992). Sand rollers are nocturnal feeders. During daylight hours sand rollers hide under the cover of structures like root wads, and undercut banks (Wevers et al. 1992), and are therefore not typically sampled during conventional daytime fish surveys. They typically feed over sandy substrates, preying primarily on aquatic insects (Wevers et al. 1992). Juveniles may rely more heavily on zooplankton (Wevers et al. 1992).

In the mid-Columbia gravid females have been collected from January through July (Wevers et al. 1992). Egg production ranged from 1,106 to 3,369 (Wevers et al. 1992). Sand rollers spawn in the mid-summer in water temperatures from 57-61F (Wevers et al. 1992). In mid-August emergent fry were collected from the Columbia and larger fry were collected in mid-September (Wevers et al. 1992).

Oregon Chub

The Oregon chub is a small minnow, growing to a maximum length of about 3 inches (ODFW 1999). Endemic to the Willamette basin, this fish used to flourish in lowland areas, preferring shallow slow moving water in areas such as oxbows, beaver ponds and side channels with thick aquatic vegetation and silty or organic substrate (ODFW 1999; OCR). The Oregon chub was listed as an endangered species in 1993 and is no longer found in the Molalla River or many other locations throughout its historic range (OCR). The Oregon chub is listed as endangered under the Federal Endangered Species act, and is classified as a sensitive species by the Oregon Department of Fish and Wildlife. The decline of the Oregon chub is likely caused by the damming, draining of wetlands, channelization, and agricultural development of the Willamette Valley, which reduces off channel habitat key to the survival of the species (ODFW 1999; OCR). Along with the loss of habitat, the introduction of exotic fish has likely also lead to the decline in chub populations (ODFW 1999; OCR). The mosquito fish competes for preferred habitat, and warmwater gamefish, like bass and bluegill, prey on this small minnow (ODFW 1999; OCR).

FISH HABITAT

Few physical habitat surveys have been performed in the LMR&MC watershed. ODFW performed coarse surveys of instream habitat conditions throughout the mainstem of the Molalla River in 1980 and 1981 (ODFW, unpublished data). More recently, ABR, Inc. and Molalla RiverWatch performed habitat surveys of four reaches in the lower Molalla River in 2001 (Cole 2002) and in two reaches in Milk Creek in 2003. Despite the lack of data available to document and quantify stream and river habitat conditions, aquatic habitat has clearly been degraded throughout much of the LMR&MC watershed. Degradation has resulted from timber harvest, agricultural practices, and residential and industrial development in the watershed producing the following types of disturbance:

- Loss of riparian vegetation
- Changes in stream and rivers flows
- Barriers to fish movement and migration
- Stream channelization
- Increased sedimentation
- Increased water temperatures

ODFW HABITAT SURVEYS

ODFW has performed several habitat surveys of the mainstem Molalla River. Earlier surveys performed in the mainstem in 1980 occurred between river miles 0.0 and 20.75. These surveys summarized river size, stream shading, and spawning habitat quality for the entire 20.75 mile length (Haxton 1980, stream survey form). The survey estimated that 75,407 sq yds of fall chinook spawning gravel occur in this section of the river. The summary report states that the brood floodplain prevents much direct shading of the river and that the riparian zone along the river was generally in "good" condition.

ODFW also performed surveys on Milk Creek between river mile 0.0 and 22.0 in 1983 and estimated that approximately 7,400 sq yds of spawning gravel occurred within the surveyed section. Subsequent to these and other surveys in the Molalla watershed, Wevers et al. (1992) concluded that gravel quantity and quality were generally "not limiting" in the Molalla drainage. More recently, ODFW has performed aquatic habitat surveys of the mainstem Molalla River as part of their statewide Aquatic Inventory Project. The ODFW Aquatic Inventory Project "is designed to provide quantitative information on habitat condition for streams throughout Oregon. This information is used to provide basic information for biologists and land managers, to establish monitoring programs, and to direct or focus habitat restoration efforts" (ODFW 2003a).

ODFW Aquatic Inventory surveys of the mainstem Molalla River occurred in 1993 from the bridge crossing at Feyrer Park to Henry's Creek Falls, a passage barrier for anadromous salmonids in the upper watershed. The surveys were divided into nine reaches; only the first reach occurred within the area encompassed by this assessment. Reach 1 began at the bridge at Feyrer Park (rm ~20.75) and extended upriver 9,859 meters to the Glen Avon Bridge crossing (rm ~26.75). The ODFW stream report describes the stream reach as being unconstrained and bound by a broad valley and wide active floodplain. The reach includes 2,876 m of secondary channel units along 35% of the total reach reach length. Wetted width averaged 18.2 m, while the active channel averaged 50.8 m, and the first terrace averaged 59.1 m (surveys occurred on 9-8-93).

Other notable characteristics occurring in the reach include a high percentage of boulder-cobble dominated banks. The surveys classified 0% of the banks within the reach as actively eroding. Large woody debris scores were very low, at 1.2 pieces per 100 m, well below the ODFW stream habitat benchmark of <10 pieces signifying undesirable conditions. Lack of woody debris loading, as discussed in chapter is indicated by these stream survey data.

Stream bed substrate was dominated by cobble and boulder (77% total wetted area). Glides and riffles were the dominant habitat units occurring in the reach, representing 37.7 and

25.7% of the total wetted stream areas, respectively.

ABR HABITAT SURVEYS

ABR and Molalla RiverWatch assessed physical habitat conditions in four reaches of the lower Molalla River (i.e. within the watershed assessment area), and in two additional reaches in the upper river as part of an assessment of macroinvertebrate communities and physical habitat along the length of the river. These surveys indicated, as would be expected, that a gradient in physical habitat conditions occurs along the mainstem of the river as it flows out of the mountainous upper reaches onto the Willamette River Valley floor (Cole 2002). Among variables showing the strongest relationship with site location were stream gradient, embeddedness, sand and fine substrate, erosional habitat, and depositional habitat (Table 9.2). Stream gradient decreased with distance downriver, as would be expected given the surrounding landforms in the basin. At site 1, stream gradient was 3.8 %; stream gradient steadily decreased to ~1% at sites 5 and 6. Bankfull width increased substantially between sites 1 and 3 (Figure 9.5), largely because of lower channel constraint and the discharge of the North Fork Molalla River between sites 2 and 3. Largely in response to changes in stream gradient, erosional habitat decreased and depositional habitats (pools and glides) increased between upper to lower reaches.

All sites other than the downriver-most site had riverbeds dominated by cobble (Cole 2002). Nonetheless, riverbed substrate composition and embeddedness still showed marked differences among site locations, with greater cover by larger substrates (coarse gravel, cobble, and boulders) in the upper, high gradient reaches and with increasing amounts of fine gravel, sand, silt, and

Table 9.2. River-wide means and ranges of environmental variables selected for analysis of correlation with site location of six study reaches of the Molalla River, Oregon, October 2001. Asterisks (*) following P values indicate significant correlation (alpha = 0.05).

			Correlation with Site Location	
Variable	**Mean**	**Range**	**Spearman's rho**	**P value**
Embeddedness (%)	25.5	7.8 - 62.0	1.000	0.001
Thalweg depth (m)	0.9	0.7 - 1.2	-0.698	0.068
Cg/cb/bd substrate (%)	82.5	50.0 - 97.0	-0.829	0.029*
Sand and fines (%)	11.3	1.0 - 36.0	0.829	0.029*
Wetted width (m)	29.9	18.9 - 36.3	0.943	0.008*
Bankfull width (m)	35.6	19.4 - 42.7	0.600	0.121
Stream gradient (%)	2.2	1.0 - 3.8	1.000	0.001*
Bank canopy cover (%)	40.5	18.5 – 65.5	0.486	0.178
Riparian canopy cover (%)	37.8	10.0 - 70.0	-0.754	0.051
Understory woody cover (%)	41.7	26.0 - 62.0	-0.698	0.068
Depositional habitat (%)	56.8	29.0 - 93.0	0.943	0.008*
Erosional habitat (%)	43.2	7.0 - 71.0	-0.943	0.008*

clay in lower low-gradient reaches, which occur within the assessment study area. Large substrate ranged from 97% at site 2 (above the assessment area) to 50% at site 6, while sand and fines ranged from 1% at site 2 to 36% at site 6. Similarly, embeddedness ranged from 7.8% at site 1 to 62% at site 6.

Riparian canopy cover, a visual estimate, was moderately correlated with site location (Table 9.2), indicating decreasing forest shading with distance downriver. Bank canopy cover, as measured by a spherical densiometer, was not correlated with distance downriver (Table 9.2). Densiometer measurements were made only from one bank at sites 2-6, thereby excluding measurements from the center of the river channel, where largest differences among sites would have been detected.

To summarize the ABR habitat surveys, the lower mainstem Molalla River changes character between the confluence with the North Fork and the confluence with the Willamette River. Stream gradient decreases from approximately 2% to less than 1%, percent erosional habitat decreases from 67% to less than 10%, and dominant substrate changes from cobble to sand (Table 9.3). Although substrate composition changes may be exacerbated by adjacent land use activities, these observed gradients in physical conditions would be expected to be present even under undisturbed conditions.

FISH PASSAGE BARRIERS

Clackamas County's Transportation Maintenance Division initiated culvert inventories throughout the County in 2002. The project, currently in progress, will include a complete inventory of all stream crossings along county maintained roads within the LMR&MC watershed. An estimated 1,311 road/stream crossings occur within the County; of these, 975 are estimated to be barriers to fish passage (Mark Mouser, personal communication). Since 1998, 20 fish passage barriers have been replaced by the county, opening 47.5 miles of stream to upstream fish passage within the watershed (Clackamas County 2002,

Table 9.3. Physical habitat conditions measured from four sample sites on the lower Molalla River, Oregon, October 2001 by ABR, Inc. (source: Cole 2002)

Site	Mean Cross Section Depth (m)	Mean Embeddedness (%)	% Coarse Gravel/Cobble/Boulder	% Sand and Fines	% Fine gravel/Sand/Fines	Wetted Width (m)	Bankfull Width (m)	Bankfull Height (m)	Stream Gradient (%)	Canopy Cover (%) w/ densiometer	Dominant Substrate	% Depositional Habitat	% Erosional Habitat
3	0.30	9.5	95	2	5	32.8	42.7	1.05	2.5	28	CB	33	67
4	0.49	25.7	86	8	9	30.3	40.2	1.20	1.8	18	CB	70	30
5	0.50	39.7	78	18	22	35.5	41.3	1.11	1.3	38	CB	76	24
6	0.72	62.0	50	36	41	36.3	40.6	1.30	1.0	46	SA	93	7

Table 9.4). Included in these projects was a single project at the Wright Road/Woodcock Creek crossing where a 96-inch corrugated culvert was replaced with a bridge and fish ladder. The new crossing has opened 8.6 miles of habitat to coho salmon, chinook salmon, steelhead, and cutthroat trout.

Table 9.4. Clackamas County fish passage improvement projects completed through 2002 in the lower Molalla River and Milk Creek watershed, Oregon.

Year Completed	**Miles Restored**	**Road Name**	**Project Location**	**Project Cost**
1998	8.6	Wright Road. Bridge 0.37	Woodcock Creek	$75,000
1999	0.2	Elliot Prairie Road. 1.09	Butte Creek	$43,041
1999	0.3	Fish Rd. 0.76	Milk Creek	$4,164
1999	2.1	Mulino Road 1.32	Unnamed Trib	$13,452
1999	2.1	Ona Way Road 0.08	Bear Creek	$12.058
1999	2.1	Steel Bridge Stockpile	Unnamed Trib	$47,978
2000	4.7	Canby Marquam 10.02	Dove Creek	$121,648
2000	1.5	Dryland Road 6.34	Gribble Creek	$45,490
2001	3.0	Dryland Road 7.80	Dove Creek	$68,160
2001	0.5	Elisha Road 0.61	Unnamed Trib	$57,214
2001	0.4	Macksburg Ro 0.40	Unnamed Trib	$38,532
2001	0.2	New Kirschner road 0.17	Unnamed Trib	$19,315
2001	3.0	New Kirschner road 1.66	Unnamed Trib	$43,087
2001	1.5	Spraque Road	Unnamed Trib	$25,456
2001	1.7	Unger Road 4.12	Unnamed Trib	$58,513
2002	0.6	Bell Road 0.04	Mill Creek	$95,199
2002	5.6	Dryland Road 4.45	Unnamed Trib	$109,108
2002	6.9	Gibson 1.46	Unnamed Trib	$105,189
2002	0.5	Howards Mill Road 0.28	Unnamed Trib	$70,447
2002	2.0	Needy Road 0.13	Unnamed Trib	$38,522
TOTAL	47.5			$1,079,527

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