Chapter 5: Synthesis

5.1 Aquatic

5.1.1 Erosion issues

5.1.1.1 Changes in erosion processes following settlement

As described in chapter 4, there is considerable evidence that human activities have altered the erosional characteristics of the watershed. In general, these changes tend to accelerate erosion. However, specific efforts have been made to implement policies that reduce erosion. In the past, forestry contributed to accelerated erosion and sediment production. Current changes to the erosion regime result from loss of vegetation, construction, and agricultural practices.

Land use activities following settlement have altered the rate and timing of erosion. Under reference conditions there were large increases in erosion rates associated with major disturbances such as fires and large storms, after which erosion rates dropped to relatively low levels. Following settlement, removal of vegetation and compaction and displacement of soil from construction have created a chronic increase in erosion rates. Conversion of forest to agriculture has resulted in local increases in sheet, rill, and gully erosion. In addition, the type of material delivered to stream channels and riparian areas from landslides has changed. Landslides were a major source of large woody debris in historical times, when there were large areas of older timber in the watershed. The large wood supplied through these processes was relatively stable in the stream system, providing structure and altering flow patterns to contribute to pool formation. With the non-forested conditions that dominate the watershed today, there is a reduced potential for large wood input to the channels from landslides. In many parts of the watershed, this is reflected in a lack of large wood and structure in the channel. Where riparian forests do exist, they are generally dominated by young hardwoods. The smaller wood provided by young timber is readily transported during high stream flows, and provides little lasting benefit to habitat structure.

These changes in watershed process have largely been the result of changes in management practices since Euro-American settlement. Although timber harvest activities originally contributed to the altered erosion regime, they currently comprise a very small portion of the watershed, and there is no indication that they are major contributors to erosion within the watershed. The greatest current contributors to erosion processes appear to be construction (urban, rural residential, and roads) and agricultural disturbances on steep lands.

Construction of roads and buildings cause many management-related erosional impacts in the watershed. In particular, construction on hillslopes contributes to the problem in several ways For example, these operations:

1. Remove portions of the slope above the road or building (the cutslope), thus making the slope less capable of bearing the weight above it;
2. Fill portions of the slope below the construction (the fillslope), thus placing an added burden to that slope;
3. Remove surface cover from the slope, thus making it susceptible to surface erosion. Additionally, drainage ditches create channeled flow, resulting in increased erosive power of runoff and increased sediment delivery to streams.

Agriculture is potentially a major contributor to erosion and stream sedimentation. Agricultural practices that tend to promote surface erosion include activities that loosen the soil and reduce vegetative surface cover. The greatest potential for such erosion occurs when agricultural activities occur on steep lands. Where such activities occur near a stream channel with an inadequate vegetation buffer, there is a high potential for sediment delivery to the stream. Additionally, the lack of vegetation on the stream bank increases its susceptibility to erosion from the stream.

5.1.1.2 Mass wasting

Steep and geologically unstable lands in the watershed remain susceptible to debris slides and slumping. Metro has identified most of the upper portion of the Tualatin Mountains as a zone of increased landslide hazard. The largest proportion of landslides following the 1996 flood events occurred in this zone, which is underlain by

Portland Hills silt. The Abbey Creek and Cedar Mill subwatersheds appear to be particularly unstable based on these factors. Portions of Cooper Mountain adjacent to streams were also identified as being unstable. Although no instability/landslide inventory exists for the Chehalem Mountains, their geologic similarity to the Tualatin Mountains indicates potential instability in this region, also.

Roads appear to be related to many of these landslides. In the Abbey Creek subwatershed, for example, ten of the landslides identified in the 1996 report occurred along Germantown Road. It follows, therefore, that many future landslides could be expected to occur along roads built on steep lands. These conditions are found most frequently in several subwatersheds draining to McFee Creek (McFee Creek, Heaton Creek, and Baker Creek), as well as two subwatersheds draining to Rock Creek (Cedar Mill and Upper Rock Creek). Similar considerations could be considered to apply to rural residential construction on steep slopes, where cuts and fills related to construction would apply the same sort of stresses to the hillslope as are caused by roads.

Hazard of sediment delivery is greatest where roads lie within 200 feet of streams (WPN 1999, Washington Forest Practices Board 1997). Stream crossings also provide a ready source of road-related sediment contributions to streams. Subwatersheds with the highest concentration of nearstream roads include McFee Creek, Cedar Mill, Abbey Creek, Upper Rock, and Heaton. In particular, Rock Creek Road parallels Rock Creek within the 200-foot zone for 2.1 miles. Christensen Creek and Blooming Creek are the only rural subwatersheds with greater than 3.5 stream crossings per square mile.

Given the above factors, it is to be expected that the greatest sediment hazard to streams would occur where nearstream roads cross steep slopes. By far, these conditions occur most frequently in the subwatersheds contributing to McFee Creek. The Upper Rock Creek subwatershed, additionally, has roughly one mile of steep, nearstream roads.

In the Chehalem Mountains and the Tualatin Mountains, lands are managed more intensively than in the mountains of the western portion of the Tualatin subbasin. Both rural residential and agricultural uses tend to reduce surface cover, resulting in increased surface runoff. The rural residential uses also tend to increase the area of impermeable surfaces, although generally this increase does not result in an appreciable change in hydrology within this watershed. Generally, these activities generate more ditches, thereby increasing the ability to transport sediment to channels. Additionally, these activities reshape the land in ways that tends to make it more erodible. The net effect of agricultural and rural residential activities in these areas is to accelerate erosion, particularly where slopes are steep.

5.1.1.3 Surface and bank erosion

An early contributor to erosion in the watershed's valleys and adjacent foothills was the extensive conversion of forestland to agricultural purposes during the latter half of the 19th century. Such conversion exposed extensive acreage to raindrop impacts and increased sheet, rill, and gully erosion. These effects would have been greatest on steep slopes and on highly erodible soils. As the conversion has largely been permanent, increased erosion remains to the present.

The degree of erosion risk is partially attributable to the natural erodibility of the underlying soils. In Washington and Yamhill counties, NRCS identified those rural lands considered to be at a high risk for erosion, based on factors such as slope and erodibility ("k") factor. The preponderance of highly erodible soils, as identified by NRCS, is located in the Chehalem Mountains. In particular, the McFee Creek, Christensen Creek, Heaton Creek, and Burris Creek subwatersheds have large proportions of highly erodible soils. Agriculture is relatively common on highly erodible lands (HEL) within these subwatersheds. In order to reduce erosion problems due to agriculture on these lands, the NRCS created site-specific HEL plans for all farms on these lands. However, compliance with these plans is not monitored annually on each farm (Dean Moberg, NRCS, Personal communication 2000).

Bank instability is prevalent throughout much of the watershed, and undoubtedly is largely related to natural factors. Along Abbey Creek, upper Butternut Creek, and other headwater streams, canyon slope is a major factor. In lower portions of the stream system, naturally erodible soil appears to be a major contributor to bank instability. Most of the Tualatin River within the watershed, as well as the lower portion of Rock Creek, is bordered by Chehalis and McBee soils, which have been identified by NRCS as being extremely susceptible to streambank erosion.

In some locations, poorly vegetated riparian buffers appear to be associated with unstable streambanks. On the Tualatin River, virtually all landslides identified through analysis of aerial photography were associated with poorly vegetated buffers. However, forested buffers may have masked small landslides along the river. Among urban tributary streams, lower Holcomb Creek displayed a particularly high association between lack of riparian vegetation and streambank instability (USA unpublished data). Although the associations were weaker in other portions of the watershed, there is a strong indication that many reaches would benefit from riparian revegetation efforts.

5.1.1.4 Trends in erosion management on rural lands

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

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

In recent years, many agricultural operations have implemented practices that reduce erosion and sediment delivery to the Tualatin River and its tributaries. Partnerships with governmental conservation agencies have been instrumental in this process. For example, the Natural Resources Conservation Service (NRCS), Washington County Soil and Water Conservation District (SWCD), and the Farm Services Agency have worked with farmers to reduce erosion and improve water quality. Methods have included programs to share costs with farmers for implementation of erosion-reduction techniques, incentives to remove riparian lands from agricultural production, educational efforts, provision of technical assistance, implementation of conservation plans, and restoration projects.

Effective erosion control in rural portions of the Tualatin Plain will largely concentrate on reduction of source sediments from agricultural operations, and from riparian restoration. The former objective is most efficiently achieved through voluntary efforts spearheaded by the NRCS and SWCD in rural areas. These agencies have a long history of working together with farmers to reduce soil loss. Additionally, these agencies are able to offer economic incentives and cost-sharing programs to implement BMPs. Although enhanced riparian buffers would be beneficial throughout the watershed, the greatest return on effort would probably occur where the riparian buffers are most severely compromised. Abundant opportunities exist in many subwatersheds, especially the **Blooming Creek**, **Middle Tualatin-Jackson Bottom**, and lower portions of the **Christensen Creek** and lower Burris Creek subwatersheds. Because of steelhead use, the lower portion of the **McFee Creek** subwatershed should also receive high priority for revegetation. .

Certain agriculturally related conditions that lead to accelerated erosion and sediment delivery to streams are prohibited under the Tualatin River Subbasin Agricultural Water Quality Management Area Plan (OAR 603-095). Such “Prohibited Conditions” are discussed in the Water Quality section (Section 5.1.4.6). Although these surveys haven’t comprehensively been performed throughout the watershed, the relatively high incidence of those conditions related to erosion control in the Hill Creek subwatershed suggest that this might be priority area for education on appropriate erosion control.

5.1.2 Hydrology and water quantity issues

5.1.2.1 Management effects on hydrology

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

The greatest impacts on hydrology have been experienced in urbanized portions of the watershed. Increased impervious surface area has resulted in decreased infiltration below the ground surface. This means that almost all of the water runs off to streams along the ground surface, with the net result that the water enters the stream more quickly than it would under natural conditions. Hydrologic effects include increased peak discharge, decreased base flow, and decreased groundwater recharge. This also creates secondary effects on the stream channel, as the stream's ability to erode the channel is increased under peak flow conditions. Many stream channels within the watershed are incised for this reason. Most of these effects are to be found in the subwatersheds contributing to Rock Creek.

Areas in agriculture have also had altered hydrology, although the effects are likely quite low relative to those prevailing in urbanized areas. These effects are likely to be largest on lands of moderate to steep slope. Although these effects are smaller than those prevalent in urban areas, it can be demonstrated that implementation of Best Management Practices is effective toward reducing the hydrologic impacts of agriculture. This has subsidiary benefits to the landowner, as well as the public, because reduced surface runoff minimizes the loss of valuable topsoil.

Generally speaking, road density in rural subwatersheds is not sufficient to contribute appreciably to hydrologic alteration. The exceptions appear to be the Heaton, Baker, and Holcomb Creek subwatersheds, which appear to have a moderate impact on hydrology.

Under reference conditions, the stream channel was hydrologically connected with extensive floodplains and wetlands. The floodplains served to moderate the volume and velocity of peak flows. While floodwaters and ponded waters were stored in floodplains and wetlands, some of the stored water infiltrated to recharge groundwater supplies. Much of the rest was subsequently released to the stream to augment lower flows. Following Euro-American settlement, stream channelization cut off many portions of the stream channel from the floodplain, thus removing the ability of the floodplain to store and moderate flows. This resulted in higher peak flows, a reduction in low flows, and increased flow velocity. Additionally, channel straightening and brush removal associated with channelization also contributed to increased flow velocity. Channel straightening increased stream gradient, while brush removal removed resistance to flow. Stream channelization also reduced the amount of recharge to groundwater, resulting in a lower water table, and diminished low flows. These changes are relatively permanent, as these channels are maintained with an artificially straightened configuration and with impaired hydrologic connection to their floodplains.

The effects upon hydrology of wetland drainage projects were similar to those of stream channelization. Like stream channelization, wetland drainage normally involved ditching to drain ponded water into the stream system. In effect, this extended the channel system, thus contributing to peak flows while reducing the amount of recharge to groundwater. Where streams naturally had surface hydrologic connection with wetlands, wetland drainage was often associated with stream channelization. Areas impacted by wetland drainage include the "Beaverdam" wetland north of Beaverton Creek, Jackson Bottom, and Fernhill wetlands. Smaller wetlands were also drained. About 10,000 acres of seasonally and temporarily flooded wetlands were converted to agricultural uses with greatly diminished flooding periods[31] .

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

Opportunities exist to restore natural hydrological functions to a limited amount of wetland. The greatest potential for such restoration exists at Jackson Bottom and Fernhill, where active wetland restoration projects are ongoing. Smaller wetlands exist within the UGB. Based on the Beaverton Wetland Inventory, about half of these wetlands have compromised hydrologic function. Depending on design, time, and effort, it is to be expected that a "natural" hydrologic regime could be simulated for these wetlands. Additional wetland restoration activities through NRCS or other parties depend on the availability of willing landowners, as well as the flexibility of other governmental entities to remove barriers to these projects.

Flow regulation, through the Tualatin River Project and Trask Reservoir have created substantial changes to the natural hydrology of the Tualatin River mainstem. Most notably, Henry Hagg Lake stores water during the winter peakflow season, thus reducing the volume of peakflows downstream of the Scoggins Dam. In the summer, water is released, resulting in an increased volume of summer low flows. Although a portion of the water is removed at the JWC diversion, most of the extra flow remains instream, where it helps to maintain water quality.

Other major changes to stream hydrology have been effected by instream diversions. These diversions have been for municipal and agricultural purposes. These diversions generally take place in the summer low-flow season. Where flow has not been augmented by water from Henry Hagg Lake, these diversions diminish stream flows below natural conditions. Diversions are common throughout agricultural portions of the watershed, with the greatest cumulative diversion occurring in the Middle Tualatin subwatershed.

5.1.2.2 Water rights allocations

Water rights appear to be fully allocated many parts of the year. In most of the watershed, no water is available for a five to six month period beginning in June. The portion of McFee Creek upstream of Gulf Canyon, however, is overallocated in all months except October. The period of overallocation in Rock Creek is shorter, extending only between July and October. This is largely a result of consumptive uses, although instream water rights significantly contribute to the deficit in McFee Creek above Gulf Canyon. As population increases within the watershed, greater demands, both for consumptive uses and for water rights, will be placed upon water resources.

USA has specified a target flow of 300 cfs at Farmington gage as desirable to achieve water quality objectives. This target flow is roughly twice USA's current flow targets. Although the Farmington gage is outside the Middle Tualatin-Rock Creek watershed, achievement of this goal would involve substantial additional summer releases from Scoggins Dam (WMG 1998).

During formulation of its action plan, the Tualatin River Watershed Council considered the purchase of additional water rights to supplement current instream water rights. The Watermaster, District 18, has determined all WABs within the watershed are a high priority for the purchase of instream water rights. Although the potential for streamflow restoration was considered to be good in most portions of the watershed, the Rock Creek WAB was considered to have a fair potential for restoration. This was because of the low number of water rights currently being used in this WAB (Darrell Hedin, personal communication). The greatest potential benefit to steelhead from supplementary instream water rights would likely accrue in McFee Creek and Rock Creek above Beaverton Creek. Further field study is necessary to establish a need for enhanced instream water rights and to determine the best location to acquire these rights.

5.1.3 Stream channel issues

5.1.3.1 Management effects upon stream morphology

Current stream channel conditions have changed from reference conditions. These changes are variable, depending upon the relative effects of altered hydrology and sediment delivery. In urbanized portions of the watershed, increased peak discharges have resulted in stream incision. In many urban and rural reaches, increased sedimentation and reduced riparian vegetation from past and current management practices have resulted in pool fill and shallower streams. Where valley walls permit, channels likely have become wider. Along some valley reaches, streams have been channelized and confined rather than allowing natural meandering.

The loss of large woody elements from the stream system has created an extensive change in channel process throughout the watershed. Under reference conditions, mature forests along the streams supplied large woody debris to the channel, creating hydraulic characteristics suitable for pool formation and increased hydraulic diversity. Following settlement, timber harvest removed large wood from the riparian zone. Channel clearing and removal of roughness elements was practiced to facilitate navigation and log drives. In the mid-1900's, stream clearing was considered to improve fish habitat and was conducted expressly for that purpose. Forest practices continued to emphasize clearing of wood from channels until the 1980's. These policies and practices have combined to generate a system severely deficient in large wood and lacking the roughness elements necessary to generate adequate numbers of pools. These circumstances have been major contributing factors to the lack of channel structure that currently characterizes many portions of the Middle Tualatin-Rock Creek watershed.

Although current levels of instream Large Woody Debris are below ODFW standards and historical levels throughout the watershed, the Tualatin River mainstem does continue to receive inputs of LWD. Field surveys indicate that these are largely the result of large (15-20" diameter) ash trees that are contributed to the channel through streambank sloughing or through windthrow. There are a number of ash trees with similar size characteristics currently on streambanks, indicating a high potential for LWD recruitment to continue at current levels. However, these inputs have a capacity to interfere with other management objectives on the Tualatin River.

Current instream woody debris, as well as recruitment potential, is quite limited on most tributaries. Although scattered large trees exist in riparian areas along the tributaries, most notably McFee Creek, most reaches lack forested riparian cover or have a canopy of young hardwoods. As there is little available nearby seed stock for natural recruitment of conifers, it is unlikely that the characteristics of these riparian zones will change. Thus, it is unlikely that any substantial natural recruitment of large woody debris will occur in the forseeable future. It may be necessary to supplement long-term development of natural recruitment with interim measures such as artificial placement of large wood. Planting of conifers in riparian areas will also contribute to long-term prospects for recruitment of large woody debris.

5.1.4 Water quality issues

5.1.4.1 Management effects on water quality

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

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

Urbanization has been responsible for many current water quality issues. The construction of the urban infrastructure requires substantial soil denudation and displacement. This, along with slope destabilization, often results in increased sediment delivery to streams. Impervious surfaces replace the natural cover, resulting in increased surface runoff, which often carries petroleum products, fertilizer, and other pollutants to streams.

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

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

Roads are notable contributors of sediment to surface water supplies. Drainage ditches associated with roads produce channeled flow, leading to increased erosion. Where these ditches lead to streams, or where roads are built in riparian zones or cross streams, an effective mechanism is created for accelerated sediment delivery and pollutant loading. This leads to higher levels of instream sediments, total suspended solids, and adsorbed particulates.

In general, flow augmentation from the Tualatin and Trask projects has had beneficial effects on water quality. Water released from Henry Hagg Lake has helped to maintain summer water temperatures below 17.8 C on the Tualatin River downstream as far as the Rock Creek treatment plant (Risley 1997). Additionally, water released from the lake is lower in nutrients than many downstream sources, and flow releases provide a dilution effect on streamflow in the Tualatin River. These releases have been instrumental in helping to achieve water quality objectives over sizeable portions of the mainstem.

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

Review of USA monitoring data from 1997 and 1998 indicate that water quality problems persist in 303(d) listed streams. All sampled sites within the watershed significantly exceed phosphorus standards. Temperature, dissolved oxygen, and bacteria also pose widespread water quality challenges in summer. In general, water quality problems are the greatest at urban sites, with the greatest overall impairment appearing to occur on Beaverton Creek, Johnson Creek (South), and portions of Bronson Creek. However, some rural streams also have severe water quality problems. Data collected by ODA indicate that Christensen Creek and Baker Creek suffer serious overall impairment. Likewise, macroinvertebrate surveys on Rock Creek indicate that water quality is significantly degraded by the time the creek enters the urban area.

Although the degree of impairment varies, no sampled streams within the watershed were found to be free of water quality problems. This indicates that significant opportunities exist to improve water quality through application of Best Management Practices in all sectors.

5.1.4.3 Factors leading to high aquatic phosphorus levels

Although aquatic phosphorus levels in the watershed are naturally high, human inputs seem to account for much of the phosphorus found in streamflow. In one study, researchers found that Tualatin Valley groundwater had a natural phosphorus concentration of 0.11 mg/L (TAC 1997). USA monitoring data indicates that many urban streams persistently have phosphorus concentrations substantially in excess of this amount. Monitored sites along Beaverton Creek, Rock Creek, and most tributaries regularly exceed this phosphorus concentration. This indicates chronic phosphorus inputs from human sources such as fertilizers and sediments dislodged by construction activities.

When revising the TMDL for phosphorus, ODEQ estimated median background phosphorus concentration as ranging from 0.04-0.09 mg/L on the Tualatin River, 0.19-0.25 mg/L on Rock Creek, and 0.10-0.16 on other tributaries within the watershed (ODEQ 2000). These figures would indicate smaller, but substantial, human inputs to instream phosphorus.

Additionally, a large component of the phosphorus in these streams appears to be imported to these sites from streams outside the Urban Growth Boundary. On Bronson Creek, for example, extremely high phosphorus concentrations (1.33 mg/L) were observed at the monitoring site at Saltzman Road. Most of phosphorus inputs at this site could be expected to come from rural activities, such as fertilization and soil disturbance related to rural residential activities.

Human inputs appear to be responsible for high phosphorus concentrations in rural subwatersheds in other portions of the subwatershed, as well. The most persistent problems appear to occur in Christensen Creek, where ODA monitoring demonstrates chronically high phosphorus levels each year. However, all tributaries appear to receive high phosphorus inputs from time to time. In 1997, very high (0.4 mg/L) phosphorus concentrations were observed on Burris and McFee creeks, while concentrations of 0.65 mg/L were observed on Baker Creek in 1999.

Some ODA data indicates that summer phosphorus levels have decreased after implementation of agricultural BMPs in the Christensen Creek watershed. These BMPs involved point source reduction from a container nursery and a confined animal feeding operation.

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

Thus, although reductions of aquatic phosphorus concentrations will vary between streams, it is still important for landowners of all sectors to implement BMPs for phosphorus.

5.1.4.4 Temperature

During summer low flows, virtually all monitored streams display some degree of temperature impairment. (The main exception is the Tualatin River upstream of Rock Creek.) The periods of excess vary between stream reaches, with high temperatures prevailing for the greatest amount of time on urbanized portions of Rock Creek and its tributaries. Beaverton Creek, Johnson Creek (South), and Bronson Creek (downstream of 185th) appear to have the worst impairment due to temperature. In the first two cases, temperature impairment is a result of impaired riparian vegetation and altered hydrology. High temperatures observed at the Bronson Creek site occur as the result of heating of water stored in a wetland upstream of 185th Avenue.

Extended periods of high temperature are also observed along most of the length of Rock Creek. This is of particular concern because ODFW considers the reach upstream of Beaverton Creek to be potentially important habitat for steelhead spawning and rearing. Although the highest temperature and the longest duration of temperature impairment exist downstream of West Union Road, monitoring by ODEQ indicates that high thermal loads occur well upstream. Thus, any solution to heating on Rock Creek will involve efforts along rural, as well as urban portions of the stream.

Canopy restoration and streambank protection (to prevent widening) are potential strategies to promote temperature moderation in many reaches within the watershed. Many perennial tributary streams have inadequate shading and would benefit from canopy restoration/erosion control projects. This includes most urban streams, especially within the Upper Beaverton Creek, Butternut, Dawson, and Rosedale subwatersheds. Additionally, many rural streams could use buffer enhancement. Examples include, but are not limited to, Blooming Creek and Christensen Creek. Riparian enhancement along lower McFee Creek, along with patches of upper and middle Rock Creek, is likely to provide benefit for steelhead rearing.

Based on recent surveys, reaches along lower and middle Rock Creek would be prime candidates for streambank protection (USA unpublished data). The middle Rock Creek area, in particular, could provide benefit for steelhead rearing. Additionally, much of Holcomb Creek would benefit from stabilization.

5.1.4.5 Bacteria

High levels of bacteria continue to persist on streams within the watershed. On monitored streams, the most severe impairment is found on South Johnson Creek and Cedar Mill Creek, both urban streams, and Christensen Creek, a rural stream. All other monitored sites (both urban and rural) were found to have beneficial uses moderately to severely impaired by bacteria.

ODEQ (2000) has identified urban runoff as a significant contributor to bacteria in streams. They further identified animal waste, illegal dumping, failing septic systems, and sanitary sewer overflows as potential sources of bacteria in urban runoff. Illegal dumping and direct deposition by animals were identified as potential sources during non-runoff periods.

In rural areas, ODEQ identified the same bacteria sources as for urban runoff. Additionally, ODEQ identified hobby farms, horse pastures, and ranchettes as additional potential sources of bacteria in runoff. Animal wastes were considered to be the largest potential source from agricultural operations.

5.1.4.6 Dissolved Oxygen

Low dissolved oxygen (D.O.) levels are a persistent source of impairment between May and October. The most severely impaired streams include Johnson Creek (South), Beaverton Creek (near 170th), and Bronson Creek. The first two creeks are in urban land use. The Bronson Creek case is particularly interesting, as a high degree of impairment is shown at one rural site (Kaiser Road) and one urban site (Walker Road), with lower levels of impairment between the two sites. Christensen Creek, a rural stream, is similarly impaired. Most other monitored streams within the watershed have beneficial uses moderately impaired because of low D.O.

High stream temperature is a significant contributor to low dissolved oxygen throughout the watershed. During TMDL modeling, ODEQ (2000) determined that oxygen demand imposed by organic material was a potentially substantial contributor to low D.O. levels in the Rock Creek (lower portions)/Beaverton Creek system. (This included organic material contained in sediment, as well as that suspended or dissolved in the water column.) Decomposition of algae was also considered to have locally important effects on dissolved oxygen. The results of this modeling were also considered to be applicable to Burris Creek and Christensen Creek, as well as other streams in the Rock Creek system.

ODEQ did not perform D.O. modeling on any rural streams within the Middle Tualatin-Rock Creek watershed. However, they modeled D.O. demand on Gales Creek, which they considered to be applicable to McFee Creek and the upper portion of Rock Creek. They found that, other than temperature, oxygen demand from organic material in sediment was the only significant contributor to low dissolved oxygen.

5.1.4.7 Biological communities

Impairment of biological communities is a persistent problem within portions of Rock Creek and its tributaries. Based on 1993 data, USGS found numerous tumors on fish in Beaverton Creek (Bonn 1999). Similarly, 1994 fish population surveys found that diversity was limited within urban portions of the watershed, and that populations were mostly comprised of pollution-tolerant species. Subsequent macroinvertebrate surveys have found low species diversity comprised of pollution-tolerant species.

Although Rock Creek is considered an urban stream, macroinvertebrate and temperature surveys indicate that problems extend well above the urban growth boundary. This is particularly important as ODFW considers upper and middle Rock Creek to be potentially important spawning and rearing habitat for steelhead trout. These surveys indicate that both urban and rural issues must be addressed to achieve water quality objectives for Rock Creek.

Although rural streams appeared to be less impaired than urban streams, biological surveys indicate that most rural streams within the watershed do not achieve the levels of biological integrity found in Roaring, upper Dairy, and upper Chicken creeks. This likely reflects the effect of fragmented land use patterns, particularly on steep lands within the watershed.

5.1.4.8 Effects of water quality on recreation

Most major streams within the watershed are considered be impaired for water contact recreation because of high bacteria levels. Diminished water quality also has indirect impacts on recreation. Poor water quality is one of the factors contributing to diminished salmonid populations, which in turn reduces cold water fishing opportunities. Conversely, relatively warm surface water temperature in the Tualatin River below Rock Creek has generated warm water fishing opportunities.

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

5.1.4.9 Prohibited conditions

Due to the lack of systematic surveys for prohibited conditions within the watershed, it is not possible to identify particular subwatersheds with high incidence of conditions prohibited under the Tualatin River Subbasin Agricultural Water Quality Management Area Plan (OAR 603-095). Subsequent to identification, a number of prohibited conditions in this and other watersheds have been successfully addressed through voluntary actions promoted by the Washington County Soil and Water Conservation District and the Natural Resources Conservation Service. This indicates that these activities are an effective pathway for addressing water quality issues.

5.1.5 Aquatic species and habitat issues

5.1.5.1 Fisheries

Winter steelhead trout and cutthroat trout make up the major focus for habitat and water quality issues in the Middle Tualatin-Rock Creek watershed. In addition to their intrinsic value, these species are sensitive to changes in habitat and water quality, thus functioning as indicator species of the condition of the stream ecosystem. Thus, measures taken to benefit salmonid populations are likely to benefit all aquatic resources. Although cutthroat trout populations in the Tualatin subbasin are not considered to be threatened, their range within the Middle Tualatin-Rock Creek subbasin is limited. Additionally, much of their rearing habitat is contained within the most urbanized and severely impacted streams within the watershed. These include Beaverton Creek, Cedar Mill Creek and lower Rock Creek. Action should be taken on these streams to improve habitat for cutthroat trout.

Declining steelhead trout trends in the upper Willamette ESU, of which the Middle Tualatin-Rock Creek watershed is a part, has led to the listing of these fish as Threatened under the federal Endangered Species Act. Although population information is limited, the reduced amount and quality of available habitat suggest a steelhead trout population that is reduced from historical numbers. For steelhead trout, habitat quality (including water quality) and quantity are likely to be limiting factors. Habitat quality is not considered to be comparable to that existing in the Gales Creek, Upper Tualatin-Scoggins, and Dairy-McKay watersheds. Nevertheless, suitable habitat for steelhead spawning is considered to exist on two stream reaches: Rock Creek above Beaverton Creek and McFee Creek below Finnegan Hill dam (ODFW 1999)[32]. These two stream reaches should be considered priority habitat restoration areas. The Rock Creek reach, in particular, should be considered for restoration as significant degradation of water quality and habitat have been found along portions of this stream. Additionally, opportunities for restoring steelhead trout rearing in the Tualatin River upstream of Rock Creek should be examined.

Poor riparian conditions in most of the watershed are likely to have a negative effect on instream salmonid habitat. Most forested stands lack large-diameter trees. Riparian forests along most tributaries largely provide a shading function, but they are unlikely to provide appreciable amounts of large woody debris during the near future. For most of the watershed, this indicates that habitat conditions similar to those existing during the reference period will not be produced naturally during the next 50 years. If riparian forests were replanted, and allowed to develop mature timber stands, they would eventually regain their ability to provide large woody debris to the stream system. However, management for this objective is likely to conflict with economic objectives within this watershed.

Lamprey species are susceptible to many of the same habitat concerns as salmonids. Increases in water temperature have provided conditions detrimental to lamprey populations. Additionally, Pacific lamprey in their larval stages make extensive use of fine substrate portions of the watershed. Thus, high water temperatures in the tributaries and the Tualatin River below Rock Creek are likely to have substantial detrimental impacts to lamprey populations. Conversely, the cool water conditions promoted by summer flow releases from Scoggins Dam may promote lamprey development in portions of the Tualatin River above Rock Creek.

Insufficient data exists to determine whether migration by anadromous fish has been impeded by human-placed structures. Although the millpond on McFee Creek forms the present limit of anadromous migration, it appears that only a short length of suitable habitat exists above the pond. Although roads and culverts potentially provide impediments to migration, an ODOT culvert survey found that all surveyed culverts on county roads within the watershed provided sufficient passage for anadromous fish. However, this survey was not comprehensive.

Migration may be inhibited by low water due to diversions. As upstream migration occurs prior to the irrigation season and enhanced instream water rights are in effect during migratory periods, migratory delay due to diversion may be minor. However, there are likely numerous unscreened diversions in the watershed, potentially providing a hazard to fish migrating and rearing in the valley channels.

The potential for potamodromous migration by cutthroat trout should also be taken into account. Although cutthroat trout are found above migratory barriers, studies have found that the likelihood of existence of a cutthroat trout population increased with length of stream above the barrier (Cramer 1997). Large numbers of stream crossings or other migratory barriers may diminish the viability of cutthroat trout populations.

5.1.5.2 Wetlands: Management impacts

The extent and functionality of wetlands have been greatly changed from reference conditions. Under reference conditions, most wetlands were shallow, seasonally flooded lakes, ponds, marshes and swamps in the Tualatin Plain. Drainage projects in the late 1800s and the early 1900s have severely diminished the extent of wetlands from pre-settlement levels. The remaining wetlands in the Tualatin Plain are greatly diminished in size, and wetland area within the watershed has been reduced by an estimated 10,000 acres, or 83%. (This excludes wetlands too small to be included in the NWI.) Although Jackson Bottom, Fernhill wetlands, and other wetland areas provide aquatic habitat for many species, they almost certainly provide less aquatic vegetation and habitat for amphibian species than did historical wetlands of the Tualatin Plain. The remnant riparian forests are the least modified wetland type. Marshes have typically been collected into impoundments with little wildlife value. Although winter ponding of traditional wetland areas still occurs, the period of inundation is greatly reduced from natural conditions, and these areas are generally no longer considered to be regulatory wetlands.

The habitat functionality of many of the remaining wetlands has been degraded. This degradation is evidenced by the encroachment of non-native noxious species upon the wetland habitats. Reed canarygrass (*Phalaris arundinacea*) is nearly ubiquitous in wetlands. Purple loosestrife (*Lythrum salicaria*), an ODA schedule B noxious weed, is also a common invader of wetland habitats. Programs to restore native plant species would help to improve the ability of wetlands to provide habitat for native animal species.

The Beaverton Local Wetland Inventory (LWI) identified 58 wetlands within its jurisdiction and performed an OFWAM assessment to determine the remaining functionality of these wetlands. All wetlands except a site on Cedar Mill Creek were considered to provide limited support for wildlife. Virtually all wetlands that had formerly supported fish habitat had lost all or a portion of that function. Hydrologic storage, however, was somewhat better supported. Forty-one of these wetlands were considered to have retained this function. Prospects for restoration for most of these wetlands ranged from moderate to low.

Current efforts to restore wetland habitats have largely been focused on Jackson Bottom, Fernhill Wetlands, and the Tualatin Hills Nature Park. Additionally, numerous small wetland restoration activities have taken place, usually in parks or as mitigation projects within the Urban Growth Boundary (UGB). Given willing landowners, there may be potential for wetland restoration outside the UGB. Agencies and organizations such as NRCS and Ducks Unlimited work with landowners to restore and enhance wetlands. However, certain obstacles exist. The cost of permits for wetland projects is often high. Additionally, these projects often require a high degree of maintenance if natural plant communities and wildlife support are desired functions.

5.1.5.3 Riparian habitat: Management impacts

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

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

Although future changes to land management rules are unclear, it seems certain that they will tend to emphasize more retention of woody vegetation on streams considered important to steelhead trout.

5.1.5.4 Impacts of wetland and riparian changes upon species

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

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

5.2 Terrestrial

5.2.1 Vegetation issues

5.2.1.1 Post-settlement effects on landscape characteristics

Due to settlement, the pattern of vegetation has changed extensively from reference conditions. The reference landscape consisted of massive expanses of late-successional forest interspersed with occasional patches of early- and mid-successional vegetation where stand-replacement fires had occurred. In the valleys, there were also patchy prairies where frequent flooding occurred. Following European settlement, the vegetation pattern was changed to the current highly fragmented landscape. The foothills are covered by a mosaic of many small patches of early and mid-successional forest, interspersed with very few small patches of late-successional forest. The largest remaining stands of these forests lie along McFee Creek and its tributaries. Additionally, the forested headwaters of Abbey Creek (and, to a lesser degree, Bronson and Cedar Mill Creek) lie adjacent to Forest Park, thus providing a large forested tract. The valleys within the watershed have been mostly transformed to agriculture, although a narrow forested riparian corridor lies along the Tualatin River and some tributaries.

5.2.1.2 Potential vegetation management strategies

Given current ownership and landscape patterns, it would be infeasible to manage the watershed for large blocks of late-successional forest. Opportunities exist, however, to manage these forests to provide small preserves and migratory corridors for species that do not require large habitat blocks. Suitable habitat for these species is an important, achievable objective in the AMAs and Riparian Reserves of federal lands. Additional opportunities lie on lands managed by The Tualatin Hills Parks and Recreation District, USA, Metro, and similar agencies. On private lands, potential to provide habitat for these species will depend upon the management emphases of the landowners. Partnership opportunities with these landowners may be available on a case by case basis. Exploring these opportunities is an important objective for federal AMA lands.

Federal, state, and private lands all provide habitat for riparian-dependent species. Assuming current management practices, the width of riparian buffer strips on private land is likely to remain narrow, and only minimal habitat will be afforded. Some of these stands will develop mature structural characteristics, providing habitat for riparian species that prefer late-successional habitats or habitat features associated with late-successional habitats.

5.2.1.3 Noxious and exotic plants

Ecosystems in the Middle Tualatin-Rock Creek watershed appear to be losing native species richness due to the invasion of exotic and noxious plants. Himalayan blackberry, Scotch broom, and reed canarygrass all provide major impacts within the watershed's foothills and valleys. Other nuisance species include Canada thistle, bull thistle, reed canarygrass, and tansy ragwort. In some cases, non-native, exotic weeds on these lands can adversely impact federal lands. Adjacent private lands are often so contaminated with exotic/noxious weeds (especially Scotch broom) that BLM-administered lands can also become easily infested unless preventative measures are enlisted to curtail it from happening.

5.2.1.3.1 Potential strategies for control of noxious and exotic plants

The fragmented ownership pattern and differing management goals within the watershed make it difficult to have a coordinated program to promote and preserve native plant populations, and limit the spread of exotic plants and noxious weeds. Himalayan blackberry and Scotch broom are two aggressive exotic plant species that are favored by soil disturbing activities, which include road building and timber harvesting. Where these plants are controlled through herbicide application, herbicides must be carefully chosen to avoid loss of native plant diversity. There are potentially additional detrimental impacts when herbicides are applied near aquatic systems. Additionally, exotic plants tend to be more aggressive than natives and invade treated areas sooner than many native plants, therefore often requiring multiple herbicide treatments to be effective. Native shrub species that are commonly greatly reduced by the invasion of exotic plants include elderberry, cascara, thimbleberry and salmonberry. Loss of these species has the potential to impact the distribution or abundance of wildlife species such as band-tailed pigeon, Swainson's and varied thrushes and black-tailed deer.

Success of eradication efforts will vary. Due to the widespread distribution and persistent nature of Scotch broom and Himalayan blackberry, it may be necessary to prioritize areas for abatement efforts, rather than attempting complete eradication within the watershed.

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

Watershed-wide, the amount of habitat available to riparian-dependent species is severely limited. For that reason, any portion of the Riparian Reserves affording cool, shaded, moist, habitat for riparian-dependent species should be retained in a condition where they fulfill that function. These areas, and those with potential to provide habitat, should be managed to promote the development of desirable habitat features. Similarly, late-successional habitat is severely deficient in the watershed. Thus any riparian areas that afford such habitat, or are capable of developing such characteristics, should be retained. Often, implementation of no cut buffers will assist in habitat retention. In some cases, thinning and projects to create snags and down wood may help in development of these important habitat characteristics. Thinning would also help to establish windfirmness within the Riparian Reserves, thereby helping to reduce future windthrow.

Portions of the Riparian Reserves occur in areas of steep, unstable terrain. Due to the risk of landslides and sediment contributions to streams, harvest activities may not be advisable in such areas.

5.2.2 Species and habitat issues

5.2.2.1 Factors affecting the distribution of sensitive species

Several factors have impacted the numbers and distribution of sensitive species within the watersheds. These include the introduction of non-native species, as well as habitat conversion and fragmentation.

The introduction of non-native species has diminished species diversity both through competition and predation. These include such species as the nutria, which reproduces quickly and competes with native mammals, the opossum, and the bullfrog. The latter, in particular, has been implicated in the loss of native amphibians throughout the western U.S. and it is likely that bullfrogs have done likewise in the Tualatin subbasin.

The majority of the watershed is currently under intensive land use, whether urban or agricultural. The remainder is a fragmented assemblage of conifers, clearings, houses and prairies. This vegetation pattern makes it difficult for any sensitive species to remain in the watershed, aside from those that only need small stands of a particular habitat type to survive.

Some such species manage to exist in the small parklands and reserves that occur in the watershed. In Jackson Bottom, for example, bald eagles are known to nest, while pond turtles and northern red legged frogs are known to live near the channels. The Tualatin Hills Nature Park, likewise, offers a refuge for such species. Both Western painted turtles and pond turtles are periodically observed, while pileated woodpeckers, river otters, and giant Pacific salamanders are observed infrequently. Botanical species of concern, as well, are observed in these habitat islands. These include *Sidalcea campestris* and the Willamette Valley bittercress (Ralph Cook, THPRD, personal communication). The fact that these parklands manage to provide habitat for such species offers encouragement that species protection can be achieved in the watershed through habitat protection.

BLM-administered lands are found in small, isolated parcels in the watershed. Forest fragmentation has led to loss of native plant diversity in the watershed. Noxious/exotic weed invasions on disturbed lands have also increased immensely, thus compounding the loss of natural habitats. Since habitat loss for species of concern is an important factor in this watershed, it is important that remaining habitats on federal lands be maintained. The value of these habitat preservation efforts will be enhanced if a partnership can be formed with private landowners to manage adjoining lands for these species.

Many sensitive species are dependent upon late-successional habitat or specific features associated with late-successional habitat. Such habitat will continue to be limited in the watershed. Some opportunities to develop these habitat characteristics may exist in federal AMAs and Riparian Reserves. Depending upon management policies, opportunities may exist to develop such habitat in lands adjacent to Forest Park (which is, itself, outside of the watershed).

The amount of snags and down woody debris available for species dependent on these habitat elements is low throughout the watershed. During field surveys, some ash snags were observed adjacent to the Tualatin River. However, snag density is far lower than would be considered optimal for species dependent on snag habitat. Large down wood is also scarce throughout the watershed and limited to local occurrences in small timber stands. Such locations include the two BLM parcels in the McFee Creek subwatersheds. Because of the lack of large trees over most of the watershed, recruitment potential is expected to remain poor. Most recruitment potential is in very small, scattered stands of mature timber along the Tualatin River and in canyons of the foothills. Active management efforts to increase levels of snags and down wood would benefit many species, including primary cavity nesters such as woodpeckers and secondary cavity nesters such as bats, flying squirrels and saw whet owls.

Due to loss of habitat, the populations of many species of concern have diminished. The spotted owl, for example, has been eradicated from the watershed due to lack of habitat. Populations of the pileated woodpecker have been reduced.

Appendix J2 of the Northwest Forest Plan and Management Recommendations for Fungi, Version 2.0, September 1997; and present protocols for category 1 and 2 lichens and bryophytes lists the ecosystem requirements for those species. The influences and relationships of these species and their habitats with other natural or anthropogenic processes are often fragile. The ROD/RMP requires that certain protection and management procedures be followed for an array of 4 categories of Survey and Manage species. BLM manual 6840 gives details on the protection and management of Bureau Sensitive, Assessment, and Tracking species. Those species potentially found in the Middle Tualatin-Rock Creek watershed are listed in sections 3.1.5.1, 3.1.5.2, and 3.2.2.1.2.

Prospects for a uniform habitat management strategy among landowners in the watershed are very unlikely. The fragmented ownership pattern restricts creation of such a strategy for sensitive species.

5.2.3 Forest resources issues [BLM-specific]

5.2.3.1 Management of snags and down wood

The quantity and quality of snags and down wood on BLM lands is generally quite low. Snags appear to be deficient in all areas. Down wood was somewhat more abundant in one of the BLM parcels (T2S, R3W, Section 23). There are areas where it would be appropriate to increase the amount of down wood by placement of fresh down Douglas-fir trees. When leaving these trees, the potential impacts to the residual stand from the Douglas-fir beetle should be considered. In westside forests, when there are more than three windthrown Douglas-fir trees per acre greater than 12 inches DBH, infestation and mortality of standing live Douglas-fir trees can be expected (Hostetler and Ross 1996). For every two down Douglas-fir trees per acre greater than 12 inches DBH, beetles will likely attack one standing live Douglas-fir tree. Not all beetle attacks will result in tree killing, however. As a general guideline, the number of standing Douglas-fir trees killed in the years following wood placement will be about 60% of the number of fresh down Douglas-fir trees added to the forest floor. However, there is some new information indicating that the number of trees killed may be as low as 25%. Tree vigor is an important factor determining whether a given tree can withstand beetle attack. Trees infected with root disease are especially at risk from beetle-related mortality. It is also important to note that the threat to the surrounding trees is much less when the down trees are exposed to direct sunlight as opposed to being shaded. Beetle attacks and subsequent brood production from exposed down trees are substantially lower than when they are shaded. Wood placed between July and September is also less likely to lead to beetle infestations.

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

5.2.3.2 Laminated root rot

Laminated root rot (*Phellinus weirii*) is a natural part of forest ecosystems in Western Oregon. At moderate levels, it is a beneficial ecosystem component, as it helps to promote structurally diverse stands composed of multiple stories and species. It can also contribute to creation of snags and down wood, although the snags produced by *P. weirii* tend to be short-lived.

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

5.2.3.3 Management of hardwood stands

An estimated 44% of forested stands in the watershed are in the mixed conifer/hardwood or pure hardwood stand condition. Bigleaf maple is by far the most abundant hardwood in forested uplands within the watershed, although red alder is common at riparian sites. Many of these sites once supported western redcedar and other conifers, but because of site disturbance during past timber harvesting activities and inadequate conifer reforestation, hardwoods have become a dominant stand component. Some of these sites are capable of supporting conifers at this time. Others are best left in hardwoods for a while to help relieve soil compaction and increase the site nitrogen level (in alder dominated sites). Some sites, such as wet areas, are probably best left in alder and not intensively managed to restore full conifer stocking. In sites currently suitable for conifer production, however, continued hardwood domination will delay the development of late-seral habitat.

5.3 Social

5.3.1 Issues related to human uses

5.3.1.1 Agriculture

The amount of farmland is expected to decrease within the watershed. In its comprehensive plan, Washington County recognized the importance of agriculture to the quality of life in the region and designated Exclusive Farm Use (EFU) zones. Most lands presently in agriculture fall within this zoning, or under the mixed Agriculture-Forestry (AF) designation. Most future losses of agricultural land to other uses are expected to occur in subwatersheds draining to Rock and Butternut creeks.

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

Although total agricultural production is a substantial portion of the watershed economy, the results of the 1997 agricultural census indicate that many farms operate on a slim profit margin. This should be taken into account when implementing new programs to address conflicts with other beneficial uses in the watershed.

5.3.1.2 Timber

Timber harvest is a relatively small-scale land use within the watershed and is primarily dispersed among small woodlands. Owners of these woodlands often combine timber growing with other objectives on these lands. Although timber lands within the watershed are very productive, the market for timber from these lands does not appear likely to improve in the near future. It is likely that small woodland owners will need to develop new strategies for marketing their products. These could include finding “niche” markets for specialty products and the formation of cooperatives to market or mill their products. However, it is likely that the value of forest land within the watershed will continue to inflate along with other lands in the Portland metropolitan area (Tom Nygren, personal communication 2000).

5.3.1.3 Rural residential and urban uses

Increasing population is probably the greatest change creating a demand on watershed resources. As population grows, demands for housing space, recreation, and workspace increase, as well as demands on water and contributions of wastewater. Population trends in Washington County indicate that these demands and pressures will continue to persist into the next century. These pressures will continue to be severe in the Middle Tualatin-Rock Creek watershed, especially in the portions of the watershed draining to Rock and Butternut creeks. Much of this growth will occur near streams, increasing potential hazards to stream resources. With this growth, there is an enhanced potential for problems related to accelerated erosion and faulty septic systems.

5.3.1.4 Rural interface

Potential rural interface problems vary within the watershed. The BLM parcel within the Upper Rock Creek subwatershed (T2S, R2W, S15) is readily accessible by road. Thus, a potential exists for public activity, such as dumping, on this parcel. The two McFee Creek parcels (T2S, R3W, sections 13 and 23) are not readily accessible, and it is doubtful that undesirable public activities will take place on these parcels.

All BLM-managed land lies within 1/4 mile of land zoned for residential parcels less than 20 acres in extent. Thus, the potential exists for conflicts between BLM management activities and the public.

5.3.1.5 Recreation

Developed parks are distributed through urban portions of the watershed. Many of these areas are designed to multiple recreational and educational objectives, including environmental education. There appear to be considerable opportunities for expanding these opportunities while providing for environmental needs. Half of the wetlands identified in the Beaverton Local Wetland Inventory, for example, were considered to support educational and/or recreational objectives, while providing other functions associated with wetlands.

With continued population growth, there is expected to be a demand for increased parklands in this area. In anticipation of this prospect, Metro's Greenspaces Technical Advisory Committee seeks to identify potential acquisitions that will satisfy both ecological and community objectives. With the limited land base available within the UGB, such multiple-objective management will become increasingly important. As with other realms of human activity, care must be taken to preserve the resource while providing for recreation.

In rural areas, the availability of BLM-managed lands for these activities is limited both in extent and access. The BLM parcels in the McFee Creek subwatershed do not have public road access. Although the Rock Creek parcels are accessible by public roads, little recreational use takes place in these parcels.

5.3.2 Cultural resources

Numerous artifacts of cultural importance have been found at locations throughout the watershed. Although care should be taken when conducting activities that might disturb areas of cultural importance, no specific cultural resources issues were identified.

5.3.3 Road-related issues

Roads can be beneficial because they facilitate access for utilization of resources, fire suppression, and recreation. However, they also have potentially negative effects. Roads frequently conflict with Aquatic Conservation Stategy (ACS) objectives by contributing sediment to streams. Exposed road surfaces are often readily erodible, while sidecasts and cutslopes are often susceptible to landsliding. Sediments are readily delivered to streams by near-stream roads and at stream crossings. The culverts at these stream crossings also frequently conflict with ACS objectives by impeding the migration of anadromous fish.

The highest risk for road-related slope failures occur on steep lands in the foothills. The Abbey Creek subwatershed, in particular, has had a particularly high incidence of road related slope failures. However, other such failures have been distributed on other roads in the watershed. These failures potentially create opportunities for accelerated sediment inputs to streams.

Stream crossings potentially create migratory hazards to anadromous fish. Additionally, insufficiently sized culverts may lead to road washouts, contributing to sedimentation problems. Recent field surveys found many inadequate culverts on forest roads. Although mainline roads have, in many cases, received properly sized and placed culverts, many older and little-used roads continue to have inadequate culverts.

Road surfacing led to a need for rock pits. Current quarries are distributed through many watersheds in the foothills and Cooper Mountain. These sites, along with historic quarries, may pose sediment risks to nearby streams. They also may create a safety hazard due to their depth and/or sheer wall faces.

5.4 Data Gaps

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

Erosion Processes

- Magnitude, location, and causes of mass wasting in the Chehalem Mountains. A comprehensive landslide inventory based on aerial photography and field visits would enhance our knowledge in this area, as well as determining present and potential sediment sources.
- Magnitude and location of sheet, rill, gully, and bank erosion. This watershed analysis identified stream reaches and subwatersheds where such erosion was observed or would be likely. Site-specific field surveys and quantitative modeling would enhance our knowledge of these processes in the watershed.
- Magnitude of erosion reduction effected by implementation of specific BMPs and relative effectiveness of these BMPs.

Hydrology and Water Quantity

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

Stream Channel

- Field verification of OWEB channel types. Field study would also provide insights on characteristics not visible from maps and photography, and would aid in restoration planning.
- Ongoing changes in channel characteristics. Field study aimed at detection of current channel migration, widening, and entrenchment would aid in planning efforts.

Water Quality

- Location of inadequate septic systems in the watershed.
- Sources of bacterial inputs in subwatersheds contributing to Christensen, Burris, and McFee creeks.
- Sources of nutrient inputs in subwatersheds contributing to Christensen, Burris, and McFee creeks.
- Sources of nutrients, sediment, and bacteria in rural portions of Rock Creek.
- Sources of heavy metals, complex organic compounds, and other toxic materials in Beaverton Creek.

Aquatic Species and Habitats

- Distribution of anadromous fish habitat. A better understanding of the quantity and quality of habitat for anadromous salmonids and other species of interest would be gained from a comprehensive habitat survey.
- Amount and distribution of salmonid spawning. Redd counts and spawning surveys would be beneficial to determine actual usage patterns by salmonids.
- Population and distribution of amphibian species. Comprehensive amphibian population surveys would help determine the distribution of sensitive species and the potential impacts of habitat loss and exotic species upon native amphibians.
- Population and distribution of special status and special attention species dependent on riparian and wetland habitats.
- Present extent, types, functions and condition of specific wetlands in rural areas. Additional information could be gained if the NWI delineation were refined using current aerial photographs and field research. Field study would also help to determine the condition of specific wetlands and locate priority sites for restoration.

Vegetation

- Amounts and distribution of sensitive botanical species. These include bryophytes, lichens, and fungi, as well as vascular plants. Comprehensive botanical surveys would facilitate planning efforts for these species.
- The composition of native plant species in a “natural” herbaceous community. Ralph Cook, THPRD, has noted that little is known about the composition of the “natural” herbaceous community in the northern Willamette Valley prior to European settlement.
- Methods by which native plant communities might be sustainably restored. Ralph Cook, THPRD, has noted the high maintenance demands necessary to maintain a “natural” landscape. More research in this area might yield lower costs in the long run.

Terrestrial Species and Habitats

- Distribution of sensitive species. Population surveys would contribute to management efforts for these species.

Human Uses

- Potential mitigation and funding sources for mitigation of rock pit sites.
- Size and condition of smaller culverts in the watershed. Washington County conducts culvert inventories, but presently concentrates its efforts on culverts exceeding 36 inch diameter.
- Historically, railroads and logging roads were built on sites throughout the watershed. Many of these “legacy roads” may continue to provide erosion and/or sedimentation hazards. However, determination of the locations of these roads, as well as potential mitigation opportunities, was beyond the scope of this report.