CHAPTER 4. DISCUSSION

4.1 AQUATIC

4.1.1 HYDROLOGY AND WATER QUANTITY ISSUES

Changes in forest age and species composition from reference conditions have probably resulted in changes to the hydrologic regime, although the magnitudes of such changes are unknown. Typically, peak flows are increased for the first 10 to 15 years following vegetation removal, after which time flows gradually return to prior levels. Impervious road surfaces and ditches may also increase flows by hastening the delivery of runoff to streams, resulting in a "flashier" peak discharge. However, increases in peak flows associated with human activities today are probably relatively minor. If harvesting increases substantially in response to Swiss needle cast (SNC) infection, impacts on peak flows will become more pronounced in the short term. We do not have a strong basis for predicting the magnitude of such impacts. Since most of the watershed occurs below the rain-on-snow zone, snowmelt from rainstorms would typically not be expected to contribute much to runoff.

Peak flows are of concern because of frequent flooding in Tillamook and other lowland areas and because of the influence of peak flows on erosion and channel stability. Twenty-nine percent of the Lower Trask River subwatershed occurs within the 100-year floodplain. A primary function of this floodplain is to reduce the severity of peak flows. Much of this function has been compromised by hydrological modifications in lowland areas. As a consequence, it is likely that flooding will continue to be an important concern in and around Tillamook.

Low-flow conditions are also of concern, because of associated effects on water quality, water temperature, and habitat suitability for aquatic biota. The monthly average Trask River low flow for August, the driest month, is about 108 cfs, based on 40 years of data. The 7-day average low flow that occurs on average only once every 10 years, or the 7Q10, is 54 cfs. We are not aware of any studies of the extent of perennial streamflow in relation to watershed area in the vicinity of the Trask watershed. However, we expect that most streams in the Trask watershed are perennial, except for the smallest headwater streams, although in late summer flows may become very low.

4.1.1.1 Management Effects on Hydrology

ODF and BLM management actions have the potential to alter water quantity and quality throughout much of the Trask River watershed. More than two-thirds of the watershed, and more than 90% of the East Fork of the South Fork and North Fork Trask subwatersheds, is in public ownership (Table 4.1).

Past and current anthropogenic changes in the hydrological regime in the uplands are attributable to accelerated runoff from road surfaces and residual effects of past logging operations and fires on runoff and stream channel morphology. We expect that the magnitude of such impacts has been decreasing steadily since completion of the salvage logging that followed the Tillamook

Table 4.1. Land ownership by subwatershed.				
Subwatershed	Stream Length (mi)	Percent Stream Length		
		ODF	BLM	Private
East Fork of South Fork Of Trask River	177	89	1	10
Elkhorn Creek	105	53	22	25
Lower Trask River	89	1.8	-	96
Middle Fork of North Fork of Trask River	81	44	16	30
North Fork of North Fork of Trask River	77	47	-	53
North Fork of Trask River	193	81	10	8.9
South Fork of Trask River	151	81	2	17
Upper Trask River	197	49	13	38
Total	1070	62	8	30

Burn fires. Ongoing hydrologic changes associated with forestry operations are expected to be minor and of short duration. Effects of future management on hydrology of ODF and BLM lands will primarily concern the planned increases in harvesting and the associated construction, maintenance, and decommissioning of roads. Reduction of roaded area, especially roads on steep slopes and in close proximity to streams, will reduce the impacts of roads on peak flows and associated erosional processes. At present, however, roads probably exert a relatively minor influence on watershed hydrology. This is because road density is not high, newer roads have been better constructed and situated, and poorly-constructed roads have had ample time in which to fail.

Hydrological changes in the lowlands have been more extensive than those in the uplands, and are probably associated with more significant ecological consequences. Conversion of forests and wetlands to agriculture during the late 19th and early 20th centuries was accompanied by extensive diking, channelization, installation of tidegates, tile draining, and ditching of lowland areas. As a consequence, the mainstem Trask River has largely been disconnected from its floodplains and wetlands. Most of these changes are probably permanent. The ability of the floodplains and associated wetlands to store water and moderate flows has been diminished, resulting in higher peak flows and reduced low flows. Peak flow velocities have increased, contributing to enhanced erosion, and low flow velocities have decreased, contributing to reduced water quality. These hydrological changes have also dramatically reduced the quantity and quality of off-stream salmonid rearing habitat.

The importance of flooding in the Lower Trask River subwatershed and the sensitivity of valley flooding to upstream watershed conditions indicates the need for a management focus on restoring natural watershed functions throughout the watershed. Flood management efforts in the lowland floodplains may be affected by the management of upland watershed conditions that influence the flow rate and volume of floodwaters. However, altered upland processes can be difficult and take a long time to restore, and we do not know to what extent there may be residual effects from the significant disturbance that was associated with the Tillamook Burns. Floodplain and wetland restoration and protection throughout the watershed could be helpful to improve flood attenuation and storage.

Water diversions have also affected hydrology, especially during summer and early fall. Some of the water has been used for irrigation, a portion of which might be expected to return to the stream system as runoff. However, such agricultural runoff is often characterized by higher temperature, reduced dissolved oxygen, and higher contaminant concentrations.

Portions of the Lower Trask subwatershed are now covered by impervious surfaces. Such surfaces increase surface runoff and decrease groundwater recharge. Because only 1% of this subwatershed is urban, however, such impacts are expected to be very small.

4.1.1.2 Water Rights Allocations

Water rights in the Trask River are over-allocated during dry months. Most existing water rights are in the Lower Trask River subwatershed, but the largest potential diversion is at Barney Reservoir, in the Middle Fork of the North Fork subwatershed. Typically, the only significant water use between November and July is municipal use; irrigation is important between July and October. The greatest cumulative effects of over-allocation occur in the lower portions of the watershed. Actual demand on water from the Trask River system varies by season and from year to year. It is likely, however, that agricultural demand is highest precisely at the times when flows would be lowest, irrespective of water use.

The mainstem Trask River and the North Fork system exhibit relatively high potential for dewatering. Summer flows are not adequate to meet consumptive and in-stream allocations, although the consumptive portion is less than one-third of the in-stream portion of the water rights. This problem further exacerbates the temperature and other water quality concerns in these areas. There is little that can be done on ODF or BLM lands to improve the low-flow situation, other than to work towards mitigation of the closely-linked water temperature problem.

4.1.2 STREAM CHANNEL ISSUES

The conditions of the stream channels have changed from reference conditions, and these changes have been most pronounced in the lower watershed. The mainstem river has been channelized and confined, and has lost its natural meandering pattern and much of its connection with estuarine and off-channel wetlands. The reduction in riparian vegetation and increased sediment load, attributable to past logging, agricultural activities, and fires, have likely made the channels wider and shallower.

The most important change in stream morphology, from a functionality standpoint, has been the loss of large woody debris (LWD). This change has occurred throughout the watershed. Under reference conditions, mature forests contained a substantial component of large-diameter coniferous trees. These trees provided LWD from blowdown in the riparian zone and from debris flows that reached the stream channel, and they created hydrologic characteristics that were conducive to pool formation, hydraulic diversity, and the retention of gravel, small woody debris, and organic material. Past timber harvest and fire removed large wood, especially coniferous trees, from the riparian zone. Furthermore, management practices encouraged LWD removal prior to the 1980s. The result of these past activities has been the development of a system that is currently deficient in structural elements necessary to generate pool formation and habitat complexity.

LWD recruitment potential is generally poor throughout the watershed. Where there are moderate to large size trees present in the riparian zone, they tend to be deciduous, mainly red alder (*Alnus rubra*). Deciduous logs decay rapidly within the stream, typically lasting less than about five years. Conifer logs, in contrast, provide beneficial effects over much longer periods of time. The historic riparian zone probably contained greater diversity of tree species and age classes, and included more large conifers than it does today. Recent changes in forest management practices will provide improved recruitment conditions in the future, but such changes will not have any appreciable beneficial impact for many decades. Interim measures, such as artificial placement of large wood, appear to have been at least partly successful within the watershed, especially in the South Fork Trask River. Planting of conifers in the riparian zone, partial cuts, and thinning in selected areas may further improve future prospects.

Channel widening results in increased stream surface area exposure to radiant energy and greater energy exchange between the stream and its environment (Boyd 1996). In addition, wider channels typically have less shading from the riparian vegetation that is present. Riparian vegetation often has a substantial impact on the width-to-depth ratio of the stream, which in turn influences water temperature and in-stream habitat characteristics. Analyses of ODFW stream survey data by ODEQ (2001) showed interquartile range (25^{th} to 75^{th} percentile values) of the width:depth ratios of 7 to 57 for annual vegetation (grasses), 18 to 38 for young forest stands, and 17 to 22 for mature forest stands. The mature stands were associated with the lowest overall width-to-depth ratios and the least variability in width to depth ratios. ODEQ did not determine whether young forest stands differed appreciably from older stands.

ODEQ (2001) estimated from digital orthophotos and field measurements the near-stream disturbance zone (NSDZ) width, as the distance between shade-producing near-stream vegetation. The NSDZ width can be considered an estimate of the bankfull width. Widths were highly variable along the Trask River mainstem, although the width generally increased with distance downstream. Because the NSDZ was frequently narrower at some downstream locations, as compared with unusually wide places further upstream, ODEQ concluded that these narrow places were, in fact, sufficiently wide to accommodate high discharge. This implies that the wider NSDZ upstream might be the result of disturbance. Management decisions concerning channel width reductions should logically target an upper limit of NSDZ as a function of distance along the mainstem. Such targets were selected by ODEQ (2001) using a moving median width value, calculated sequentially from 10 measurements along 1,000-ft stream segments. The best fit line (Figure 4.1) was used to determine an upper limit on the NSDZ width at various locations along the mainstem:

$$\text{Potential NSDZ width} = -2.84 \times \text{RM} + 143.98$$

where NSDZ is given in feet and RM is river miles from the mouth.

Areas where the estimated NSDZ width exceeded the potential NSDZ width are shown in Figure 4.1. Most areas having the largest discrepancy are located off ODF and BLM land. Other than a small section near RM12, ODF and BLM do not own much mainstem riparian area downstream from RM18.

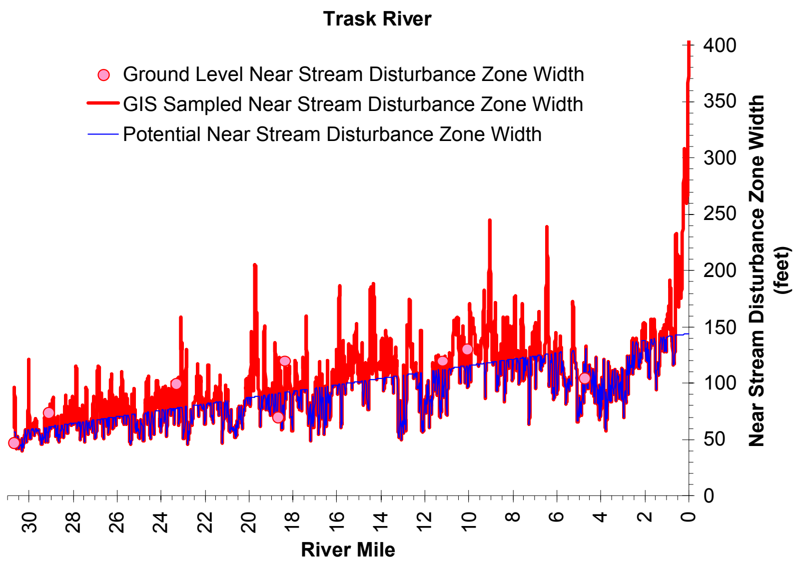

Figure 4.1. Near stream disturbance zone (NSDZ) width for the lower 30 miles of the Trask River, as determined by ODEQ based on ground measurements and aerial photo interpretation. The potential NSDZ width was calculated as: potential NSDZ width = -2.84 x (River Mile) + 143.98.

Channel morphology downstream of ODF and BLM land in the Lower Trask River subwatershed has been dramatically altered by channelization and flood control efforts. Early dredging, logging, and log transport activities removed roughness elements from the channel and also removed most of the natural mix of riparian vegetation. Subsequent channel straightening, diking, and ditching have contributed to channel incision in some places and disconnection of the river from most of its floodplain. Current land uses limit the prospects for restoration of the functionality of the lower river and its associated wetlands and floodplain. However, the Tillamook Estuaries Partnership has recently been involved in land purchase and restoration actions to restore some of the estuarine wetland functionality.

ODEQ (2001) estimates of potential channel width for the mainstem Trask River from the mouth to RM30, based on estimates of current median width, gradually increased from headwaters towards mouth (Figure 4.1). The analysis suggested that the channel width has increased in many areas above RM6, but decreased between RM2 and 6 (the latter effect was probably attributable to diking). The estimated changes in channel width above RM6 were simulated by ODEQ to impact stream temperature, along with changes in riparian vegetation. The increased current near-stream disturbance zone and wetted widths, compared with simulated potential conditions, are believed to result in increased stream surface area and decreased shading of the mainstem Trask River, both of which would contribute to increased stream temperature.

The steep narrow valley (SV) and very steep headwaters (VH) channel habitat types (CHTs) predominate within all subwatersheds except the Lower Trask River. These CHTs have probably not been modified as dramatically by human activities since European settlement, in part because they are often very inaccessible. LWD in these CHTs cycle through phases of accumulation and release by debris flows. Overall, LWD abundance in SV and VH channels was probably greater prior to the Tillamook Burn.

Moderate gradient moderately confined (MC) and moderately steep narrow valley (MV) CHTs account for 20% to 30% of the stream channels in the upper watershed (Table 3.6). MV streams, in particular, probably contained a moderate amount of LWD prior to European settlement. It is possible that areas of extensive in-channel exposed bedrock, for example in the North Fork of the North Fork subwatershed, may have lost some of their former soil and sediment cover from erosion subsequent to past logging and fires. Such a change may have contributed to increased stream heating. The less common (4% to 7% of the uplands) moderate gradient moderately confined (MM) CHT probably historically contained abundant LWD, and is considered most responsive to restoration activities such as LWD emplacement (Table 3.6).

4.1.3 EROSION ISSUES

4.1.3.1 Changes in Erosional Processes

Erosional processes are believed to be different now, in both rate and timing, than they were under reference conditions. Historically, erosion rates were probably generally lower than they are currently, but they increased dramatically in association with periodic fires and large storm events. Such increases in erosion were generally short-lived. Erosional events were always largely episodic in nature, but it is likely that high stream flows elicit more erosion today, as compared with historic times, because of additional sediment contribution by roads. We would expect that rates of erosion throughout the watershed reached their peak shortly after the Tillamook Burn fires and associated salvage logging, and then decreased substantially after revegetation.

Debris flows constitute the principal erosional process in the Trask River watershed. They generally occur in response to large storm events, and often are associated with roads and, to a lesser extent, clearcut harvests. To some extent, debris flows are beneficial, providing sediment and LWD to the stream system. Throughout the Oregon Coast Range, past road-building, logging, and fires increased the frequency of debris flow occurrence, contributing to increased sedimentation in the lower rivers and bays. Although there is a lack of Trask-specific data, we would expect the same to have been true in the Trask watershed, since geological, disturbance, and vegetation conditions have been similar to neighboring watersheds. Improved road construction and logging practices have reduced this impact throughout the Coast Range.

Bank erosion is also important throughout the watershed. Based on results obtained in ODFW stream surveys (109 miles on 23 streams), approximately 14% of the stream banks in the Trask River watershed are actively eroding. Bank erosion in mature riparian stands would be expected to be very low (Table 4.2). The highest levels of bank erosion were recorded in the East Fork of the South Fork (30%), Elkhorn Creek (30%), and Lower Trask (23%) subwatersheds.

Established and mature woody riparian vegetation adds the greatest rooting strength to the streambank and the greatest flood plain/streambank roughness; annual riparian vegetation (e.g., grasses) adds the least. Streambank erosion rates for Tillamook Basin rivers, analyzed by ODEQ, are given in Table 4.2, showing dramatically lower median percent of streambank actively eroding for banks dominated by mature forest, as opposed to young forest stands or annual vegetation. Efforts to increase the extent to which riparian areas are occupied by mature forest types would be expected to decrease bank erosion.

Table 4.2. Relationship between riparian vegetation type and percent of stream bank actively eroding, based on ODFW survey data in the Tillamook Basin. (Source: ODEQ 2001)

Riparian Vegetation Type	Median Percent of Stream Bank Actively Eroding
Annual (grass-dominated)	37
Young Hardwood	18
Young Conifer	16
Mature Hardwood	3
Mature Conifer	0

The type of material delivered to the stream and estuary systems has also changed. During historic times, landslides and, to a lesser extent, blowdown provided abundant LWD to the stream system. This LWD was relatively stable in some portions of the stream channel because of its large size, the abundance of large trees along the stream bank which served to anchor the LWD, and the generally narrower channels that prevailed at that time. This LWD contributed structure to the channel, altered flow patterns, dissipated stream energy, reduced bank erosion, retained gravel, and promoted pool formation. It also contributed some LWD to the estuary, which would have provided increased estuarine habitat complexity.

There is little input of large wood to the stream system today because the forests, and especially the riparian areas, are dominated by smaller trees. The smaller wood contributed by landslides today is more easily transported downstream during high flow periods and provides little structural complexity to the channel system.

4.1.3.2 Management Impacts on Erosion

Changes in erosional processes have occurred as a result of land use practices since Euro-American settlement and the Tillamook Burn fires. The principal historic land use activities that have contributed to increased current erosion rates were road building and logging in the uplands and practices associated with agriculture and flood control in the lowlands (especially vegetation removal, channel straightening, diking, and wetland draining).

The legacy of land use within the watershed probably continues to cause accelerated erosion today, but the magnitude of effect is not known. In the uplands, human-caused erosion is probably most strongly associated with the presence of roads, especially those in closest proximity to stream channels and on steep slopes (Plate 12). In the lowlands, the absence of intact riparian vegetation and the continuation of land disturbing activities along stream channels contribute to accelerated bank erosion.

Logging practices improved substantially subsequent to passage of the Oregon Forest Practices Act in 1973. Practices are now mandated, including riparian buffers and cable yarding on steep slopes, to reduce soil disturbance and retain riparian vegetation during logging operations. More recent forestry operations cause less erosion than previously, but effects from past practices probably persist to some extent.

Conversion of lowland forest and wetland areas to agriculture during the 19th and early 20th centuries contributed substantially to bank and surface erosion. In addition, many sediment deposition areas were bypassed or eliminated and the lower river was channelized, thereby contributing to enhanced sediment transport from the river to Tillamook Bay. Such impacts continue to the present. The increased peak stream velocity that has resulted from channelization and diking has increased the erosion capability of the Trask River. In addition, the clearing of vegetation along the lower riverbanks has reduced bank resistance to erosion. Some of these changes are probably irreversible. Erosion due to agricultural practices has been reduced to some extent by implementation of Best Management Practices (BMPs), although such changes do not appear to have been dramatic or widespread in recent years. Riparian restoration and planting efforts should continue to make modest improvements in bank stability. Greater reductions in erosion on agricultural lands might be achieved by bringing more farms under Voluntary Farm Water Quality Management Plans.

4.1.3.3 Potential Future Sources of Sediment

It is likely that future sources of sediment to the stream system will continue to include legacy effects of past road construction, fire, and logging operations. In general, however, such erosional sources will probably continue to diminish in importance over time as problem culverts are replaced, roads are upgraded or decommissioned, and forest and riparian vegetation continue to develop. Future logging and associated road building may contribute new sources of erosion, but proper road design, maintenance practices, and careful adherence to current management practices should minimize such impacts. It will be important to carefully consider management actions, especially those associated with roads in landslide hazard locations, in consultation with geotechnical specialists.

4.1.3.4 Priority Locations for Projects to Address Erosion Issues

Steep lands within the watershed are susceptible to landslides and debris flows, even with no disturbance. Much of the watershed is on steep terrain, especially in the South Fork, Upper Trask, and North Fork subwatersheds, and in proximity to the mainstem within the North Fork of the North Fork and the Elkhorn Creek subwatersheds. Management decisions regarding steep lands should be carefully considered, possibly avoiding land-disturbing activities in such areas.

Current management-related erosional impacts in the Trask River watershed uplands are largely attributable to roads, which are subject to erosion of fillslopes, cutslopes, road surface (of unpaved roads), and ditches. In steep areas subject to shallow, rapidly-moving landslides, roads increase the risk of slope failure on both the underlying slope (oversteepened and low strength) and the slope above the road (oversteepened). Drainage ditches associated with roads route surface runoff, thereby contributing increased sediment delivery if the ditches are hydrologically connected to streams.

Erosion control efforts in upland portions of the watershed should be especially focused on areas subject to recent or ongoing land-disturbing activities. Particular attention should be paid to midslope roads in steep areas with high debris flow hazard, especially such areas that include many road/stream crossings (Table 4.3) and those that have high road densities (Table 4.4). The presence of roads within 200 ft of a stream on steep terrain is a particular cause for concern. Such roads are not common within the watershed, but are most prevalent in the North Fork Trask and North Fork of the North Fork subwatersheds (Table 4.5, Plate 12). For more information on roads and erosion, see section 4.2.1.

Areas that are experiencing high bank erosion, including the East Fork of the South Fork, Elkhorn Creek, and the Lower Trask River subwatersheds, should also be considered good candidates for erosion control actions where it is determined that the bank erosion is partly attributable to human activities. These could include such actions as riparian planting, LWD emplacement (in appropriate CHTs), culvert replacement, and road repair and decommissioning.

4.1.4 WATER QUALITY ISSUES

Water quality in the Trask River, especially above the forest/agriculture interface, is generally good for most parameters of interest. Some water quality degradation has occurred, however, since Euro-American settlement, mostly involving increases in water temperature and fecal coliform bacteria (FCB) concentration in some areas. High temperature has been found to occur during late summer and early fall, especially in the Trask River mainstem and North Fork Trask River mainstem areas. Bacterial problems are primarily confined to areas downstream from the forest/agriculture transition. Localized lowland areas (primarily the sloughs) exhibit low dissolved oxygen and may be at least periodically inhospitable for biota. Nitrogen (N) concentrations have increased over the last four decades, probably due to the increased prevalence of N-fixing alder stands in riparian areas. Phosphorus (P) concentrations during stormflow are probably higher than under reference conditions due to erosional inputs of geologic material that has naturally high P content.

Among the five rivers that flow into Tillamook Bay, the estimated annual loading rate for FCB (cfu per unit time) was highest for the Trask River (2,000 to 3,200 x 10^{12} cfu/year). Similarly, the estimated total suspended solids (TSS) loading (mass per unit time) for the Trask River (185 x 10^{6} kg/yr) was second only to the estimate for the Wilson River (314 x 10^{6} kg/yr), and the estimated total inorganic nitrogen loading (which can contribute to eutrophication of the bay) was highest for the Trask River (1.1 x 10^{6} kg/yr; Sullivan et al. 1998b). Thus, the Trask River watershed accounts for proportionately more pollution (bacteria, sediment, nitrogen) loading to

Table 4.3. Available data regarding condition of culverts and roads on ODF lands by subwatershed. (Source: ODF roads database).

Subwatershed	Subwatershed Area (sq mi)	Road Length (mi)	Road/ Stream Crossing	Culverts (Stream Crossings) Collapsed/ Blowout Culverts	Damaged Culverts[a]	Total Culverts Surveyed	Roads (mi) Fill Condition (Steep/Water)	Slide Activity (Drop/ Slide/Crack)	Downslope Risk (High)
EF of SF Trask	29.0	87.9	155	2	12	32	11.9	15.2	13.7
Elkhorn	17.3	35.6	70	0	16	35	3.7		5.1
Lower Trask	22.5	1.9	1	0	3	3			
MF of NF Trask	13.2	18.9							
NF of NF Trask	12.7	22.5							
NF Trask	29.3	70.1	182	5	8	52	13.4	20.7	12.1
SF Trask	23.3	49.4	99	4	19	51	10.4	6.7	0.8
Upper Trask	27.6	39.0	82	0	21	51	11.1	7.6	0.4
Grand Total	174.9	325.1	589	11	79	224	50.5	50.2	32.1

[a] Damage based on visual inspection for mechanical damage, rust, and sediment build-up

Table 4.4 Road density in subwatersheds of the Trask watershed.		
Subwatershed	Area (mi^2)	Road Density (mi/mi^2)
East Fork of South Fork of Trask River	29	3.6
Elkhorn Creek	17	3.8
Lower Trask River	22	5.6
Middle Fork of North Fork of Trask River	13	2.8
North Fork of North Fork of Trask River	13	5.6
North Fork of Trask River	29	3.0
South Fork of Trask River	23	2.8
Upper Trask River	28	3.2
Total	175	3.7

Table 4.5 Length of road segments less than 200 ft from a stream and on steep slopes (>50%, >65%, and >70%), by subwatershed.

Subwatershed	Road Length Surveyed (mi)	Length <200 ft from Stream (mi)	Length <200 ft from Stream and on Steep Slope (mi)		
			>50% Slope	>65% Slope	>70% Slope
EF of SF Trask	105	16.9	0.7	0.1	0.1
Elkhorn	66	11.0	1.9	0.7	0.4
Lower Trask	126	10.8	0.6	0.3	0.2
MF of NF Trask	37	6.0	0.2	0.01	-
NF of NF Trask	71	13.2	2.9	0.6	0.3
NF Trask	86	14.4	3.2	1.2	0.8
SF Trask	64	11.1	1.4	0.4	0.3
Upper Trask	89	14.7	2.2	0.8	0.4
Total	645	98.2	13.1	4.1	2.6

the bay than any of the other rivers in the Tillamook Basin. Nevertheless, in comparison with other rivers in western Oregon, water quality in the Trask River is considered fairly good.

4.1.4.1 Temperature

Stream temperature is of vital importance to salmonid health and well-being. It influences the metabolism, growth rates, availability of food, predator-prey interactions, disease-host relationships, and timing of life history events of fish and other aquatic organisms (Spence et al. 1996). Temperature requirements vary by species and life stage (Table 4.6), and conditions most frequently approach harmful levels in the late summer when air temperatures are high and streamflows are low.

Table 4.6. Optimum and lethal limit stream temperatures for coho and chinook salmon. (Source: ODEQ 1995)		
	Fish Species	
	Coho	Chinook
Preferred juvenile temperature range	54-57°F	50-60°F
Adult migration, holding or spawning	45-60 °F	46-55°F
Lethal limit	77 °F	77 °F
State water quality standard for rearing and migration	64 °F	64 °F

Many studies have concluded that stream temperature increases in response to timber harvesting, especially when vegetation is removed up to the edge of the stream (Levno and Rothacher 1967, Meehan 1970, Feller 1981, Hewlett and Fortson 1982, Holtby 1988, ODF and ODFW 2002). Allowing riparian vegetation to remain near the stream has been shown to reduce the effects of harvesting on stream temperature (Brazier and Brown 1973, Kappel and DeWalle 1975, Lynch et al. 1985, Amaranthus et al. 1989, ODF and ODFW 2002). Consequently, forest management policies now require the maintenance of a riparian vegetation buffer along streams on private, state, and federal lands. A study conducted by ODF to assess the effectiveness of Riparian Management Areas found that the state water quality temperature standard (64 °F) was exceeded 9.4 % of the time, and concluded that, "…consistent, if not significant, increases in stream temperature below harvested reaches indicate that the forest protection rules may not always provide adequate protection to meet water quality standards" (Dent and Walsh 1997). However, this study focused on medium and large streams, and lacked pre-harvest data for comparison. In general, the response of stream temperature has been found to vary based on stream size and the amount of stream surface exposed by harvesting. When more forest canopy is removed, more solar radiation reaches the stream surface, increasing the temperature (Beschta et al 1987). For small, headwater streams, there is the potential for temperature increases to diminish within 500 ft downstream of harvest activity, although the magnitude of recovery is highly variable (Caldwell et al. 1991, ODF and ODEQ 2002).

Riparian corridors develop a microclimate characterized by cooler air temperatures and higher relative humidity as compared with unvegetated streamside areas. For example, riparian vegetation removal increased near-stream air temperatures by up to 8EF, based on research along 20 small streams in western Washington (Dong et al. 1998). Near-stream ground temperatures can be an even greater source of heat to the stream because the heat conductivity of soil is typically 500 to 3,500 times greater than that of air (Halliday and Resnick 1988). Brosofske et al. (1997) estimated that a minimum stream buffer width of 150 ft was required to maintain soil temperatures that reflect those of a normal microclimate.

Shade Analyses

In the Trask watershed, three assessments of stream shade have been conducted over the past decade. Shade conditions were recorded by ODFW field crews during stream habitat inventories between 1990 and 1997. The mainstem of the Trask River, the North Fork, and the North Fork of the North Fork were studied and shade was modeled by ODEQ for the TMDL. Finally, ODF commissioned a graduate student to study and map stream shade from aerial photos (Falcy 2002). The ODFW and ODF studies produced similar results with regard to stream shade. Based on the stream shade analysis of ODF lands by Falcy (2002), the subwatersheds having the lowest percentages of stream in the high (> 70%) shade category are the Lower Trask (43%), Upper Trask (86.3%) and North Fork of the North Fork (87%) subwatersheds (Table 4.7). All other subwatersheds were judged to have at least 93% of the stream length on ODF lands rated as having high shade.

Table 4.7. Stream shade on ODF land (Falcy 2002)

Subwatershed	Stream Shade					
	Low (< 40%)		Medium (40-70%)		High (> 70%)	
	mi	%	mi	%	mi	%
East Fork of South Fork of Trask River	1.8	1.4	0.4	0.3	128.4	98.3
Elkhorn Creek	0.9	1.9		0.0	44.8	98.1
Lower Trask River	0.5	32.6	0.4	24.3	0.7	43.0
Middle Fork of North Fork of Trask River	0.7	1.9	1.2	3.2	36.1	94.9
North Fork of North Fork of Trask River	1.5	4.8	2.6	8.1	28.1	87.1
North Fork of Trask River	2.3	1.6	2.6	1.8	135.2	96.5
South Fork of Trask River	4.9	4.8	2.2	2.2	94.8	93.0
Upper Trask River	6.6	8.7	3.8	5.0	65.3	86.3
Total	19.3	3.4	13.2	2.3	533.4	94.3

Similar results were obtained by ODFW in their aquatic inventories, which included stream lengths on BLM and private lands as well as ODF lands (Table 4.8). The lowest shade was found in the Lower Trask (32%), Upper Trask (60% to 67%), and the North Fork of the North Fork (72% to 79%) subwatersheds. Shade conditions were frequently above 90% in other subwatersheds. These data suggest a particular need for shade-enhancing activities by private landowners in the Lower Trask subwatershed, and by all ownership classes in the Upper Trask subwatershed and throughout the North Fork of the North Fork tributary system.

ODEQ measurements of shade are summarized for the mainstems of the Trask River, the South Fork, and the North Fork (including the North Fork of the North Fork) in Figure 4.2. Shade levels were lowest for the Trask mainstem, at 30% canopy cover, and the North Fork was 61% canopy cover. The South Fork had the highest canopy cover, at 91% (Figure 4.2). Field measurements of effective shade and canopy cover by ODEQ are currently about 40% higher in

Table 4.8. Average percent stream shade from ODFW Aquatic Habitat Inventories (1990-1997).			
Subwatershed	ODF	BLM	Private
East Fork of South Fork of Trask River	93.7		96.3
Elkhorn Creek	93.6	91.0	91.4
Lower Trask River			32.0
Middle Fork of North Fork of Trask River	82.8	76.0	97.0
North Fork of North Fork of Trask River	79.2		72.0
North Fork of Trask River	80.9	67.7	98.0
South Fork of Trask River	92.3	100.0	95.1
Upper Trask River	60.6	63.3	67.8
Total	83.3	79.6	81.2

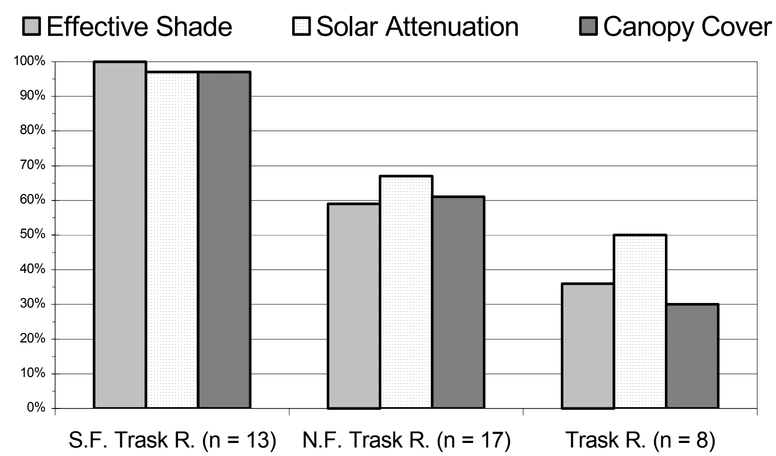

Figure 4.2. Comparisons among the mainstem South Fork, North Fork, and Trask River subwatersheds with respect to effective shade, solar attenuation, and canopy cover, based on ODEQ data, which did not go far up into the tributaries. (Source: ODEQ 2001).

the South Fork Trask River mainstem than they are in the North Fork mainstem (Figure 4.2), and this is likely an important reason for the higher stream temperatures in the North Fork mainstem (Figure 4.3).

GIS analyses also indicate that the North Fork of the North Fork system has a greater percentage of its drainage basin facing to the south (" 45E) than does the upper South Fork system (31% versus 20%). In addition, the geomorphology of the North Fork of the North Fork subwatershed may contain fewer springs and seeps, and exhibits lower summer flows (c.f., Falcy 2002). Thus, it is perhaps not surprising that the North Fork mainstem is consistently warmer than the South Fork (Figure 4.3), and the differences become more pronounced later in the season as the water temperatures increase. By late summer in 1998, the North Fork was about 4EF warmer than the South Fork.

It has been hypothesized that current shade conditions in many areas may actually be higher today than prior to Euro-American settlement (ODF and ODEQ 2002). Based on a comparison of historical forest age class distributions from 1850 to 1929 by Botkin et al.(1995) and current age class distributions on non-federal lands (Robison et al. 1999), it appeared that much of the area that was once occupied by age classes that provided “moderately high” to “very low” shade (the 0 to 3 yr and 200+ yr age classes), are now covered by age classes that provide “moderate” to “very high” shade levels (the 4 to 50 yr age class; ODF and ODFW 2002). However, the specific distribution of forest age classes in historical times in the Trask watershed, and the degree of shade provided by each, is unknown. Furthermore, the degree to which riparian vegetation was similar to upslope vegetation is also uncertain.

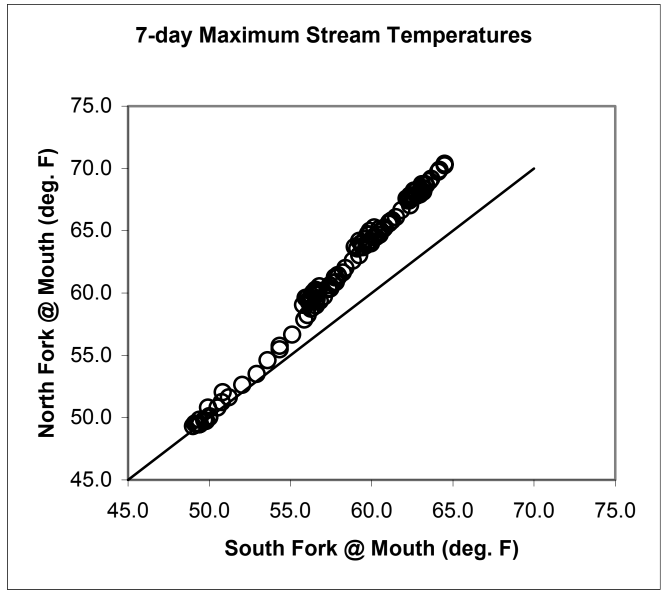

Figure 4.3. Comparison of 7-day maximum stream temperatures during the period May to October 1998 between the North Fork and South Fork Trask River (@ mouths). (ODEQ data)

Stream primary productivity can be augmented as a result of increased light reaching the stream, and this can add to the available food for salmonids (MacDonald et al. 1991, Murphy and Meehan 1991) and also can increase salmonid production and/or growth in the short term (Tschaplinski 1999). Under reference conditions, it is likely that shade was higher along mainstem reaches, but perhaps was generally lower and more variable than it is today at many upstream locations.

Temperature Monitoring

Whereas assessments of shade are frequently used as a means of estimating water temperature conditions in the absence of temperature data, several studies in the Trask have gathered stream temperature data using automated data loggers.

Falcy (2002) collected continuous stream temperature data at 16 upper tributary sites in the Trask River watershed between late July and late September, 2002. None of the monitors recorded a 7-day moving mean of daily maximum temperature above the 64EF critical value for salmonid migration**.**

In contrast, based on ODEQ continuous temperature monitoring data, stream temperatures were above desirable levels for extended periods of time during July through October, 1998 along the mainstems of the Trask River, North Fork and North Fork of the North Fork. These stream reaches had been included on the 303(d) list for temperature, but are now under a TMDL. The best (coolest) temperature conditions were found in the South Fork of the Trask system. Based on ODEQ data collected in 1998, early August temperatures in the Trask River were generally in the upper 50EF range in the headwaters and warmed to the 70EF range in the lower river (Plate

13). The temperature criterion to protect migrating salmonids is 64°F, but it is not known if the lower river was usually below that value, even under reference conditions.

It is important to note that the temperature monitoring data collected by Falcy in 2002 and ODEQ in 1998 are not necessarily in conflict. The former showed small tributary reaches below the salmonid migration temperature criterion and the latter showed some mainstem reaches above the criterion. It is not known whether conditions differed between study years or to what extent the measured high temperatures in 1998 were confined to mainstem reaches.

High stream temperatures along the mainstem streams were attributed by ODEQ primarily to historical near-stream vegetation disturbance and removal, and secondarily to channel modifications and widening, with consequent increased width-to-depth ratios (ODEQ 2001). In addition, it is possible that riparian disturbance from the 1996 floods temporarily reduced shading in some areas. Stream temperatures have been shown to increase in the Oregon Cascade Mountains in response to debris flows that removed riparian vegetation (Johnson and Jones 2000).

ODEQ found that water temperatures in the Trask River headwaters are often more than 10EF cooler than near the mouth, and vary in a consistent fashion with distance from headwaters (Figure 4.4). To some extent this pattern is driven by shading, which is much reduced in lowland areas. It is also likely, however, that water temperatures would rise as the water moves downstream even if maximum potential shading was realized basin-wide, largely because the stream becomes wider than the cover provided by vegetation. Thus, there is a natural component to this observed pattern, but it is also influenced by past and present land use and land cover.

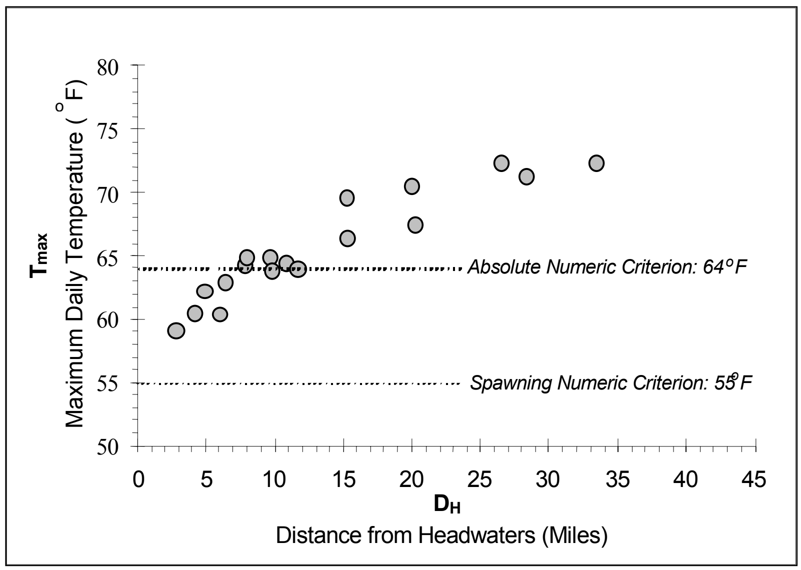

Figure 4.4. Maximum daily temperature in the Trask River as a function of distance from headwaters. (Source: ODEQ 2001)

Limited time series data suggest that stream temperatures may have generally been decreasing in recent decades (Figure 3.16), probably in response to continued gradual vegetation development subsequent to large-scale deforestation associated with the Tillamook Burn fires and salvage logging. Despite apparent recent improvements, however, stream temperatures exceeded the salmonid migration criterion for extended periods of time in 1998 at several locations (Table 3.12).

ODEQ Modeling

A limiting factor in our ability to reduce the extent of longitudinal stream heating is the natural maximum level of shade that a given stream is capable of attaining, based on tree height, stream width, and stream aspect relative to solar azimuth. The site potential effective shade (ES) is defined as the effective shade of that stream, given the natural stream geometry and mature riparian vegetation. Effective shade is given by (c.f., ODEQ 2001):

$$ES = \frac{Solar_1 - Solar_2}{Solar_1}$$

where $Solar_1$ = potential daily solar radiation load in the absence of vegetation, and

$Solar_2$ = measured daily solar radiation load at the stream surface.

There is a strong inverse relationship between effective shade and temperature of largely mainstem reaches in the Tillamook Basin (Figure 4.5). ODEQ concluded that these data suggest that an effective shade of 80%, averaged over all reaches analyzed by ODEQ (2001), would likely result in stream temperatures below the 64EF water quality standard. However, it is unclear to what extent 80% effective shade is achievable on the wider mainstem reaches.

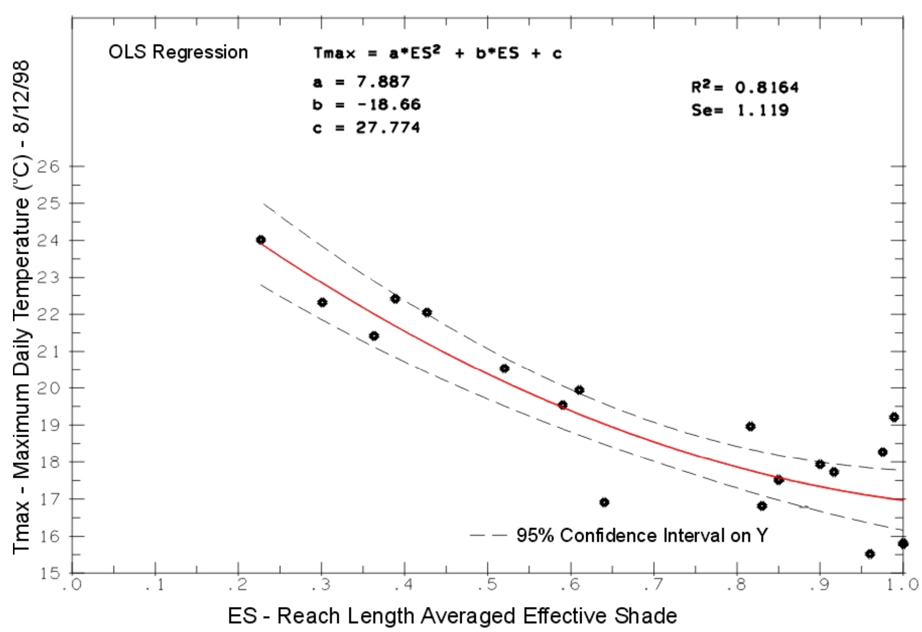

Figure 4.5. Maximum daily stream temperature as a function of reach length averaged effective shade for rivers throughout the Tillamook Basin. (Source: ODEQ 2001)

In the areas of the Trask River where temperature criteria are exceeded, ODEQ considers attainment of "system potential" temperature conditions, as measured by percent effective shade, to demonstrate compliance with the temperature standard. This compliance is intended to be obtained through protection and restoration of riparian vegetation, channel morphology, and hydrologic processes. ODEQ (2001) simulated, using Heatsource 6.5, the thermal effects on system potential riparian vegetation and channel morphology, thereby minimizing the influence of human-caused increases in stream temperature.

ODEQ (2001) analyzed and simulated 74.6 miles of the mainstem Trask, Wilson, and Kilchis Rivers during the critical period (August 12, 1998). This analysis suggested that 59% of the mainstem river reaches had temperatures in the range of 68EF to 72EF, and 24% of the river reaches exceeded 72EF. In contrast, the actual measured ambient temperature conditions showed 98% of the analyzed mainstem reaches currently having maximum daily water temperature during the critical period greater than 64EF, with about 85% exceeding 68EF, and 24% exceeding 72EF (Figure 4.6). The simulated system potential condition suggested that 73% of river reach should have temperature between 60EF and 64EF, 26% between 64EF and 68EF (and therefore above the standard), and no temperatures above 68EF.

ODEQ modeling conducted for the Tillamook Basin TMDL also suggested that ground-level shade along the mainstem Trask River decreased from near 80% at RM 30 to near zero at RM 0, and that there was an increasingly larger divergence downstream between current shade conditions and model estimates of system potential shade. The model results suggested that the system potential shade exceeded about 50% throughout the entire mainstem. In contrast, estimated current shade was less than 50% in most portions of the mainstem within about 26 miles of the mouth. The system potential shade was simulated using the Heatsource 6.5 model by increasing tree heights and densities to those expected in mature riparian communities, assumed to be 125 ft in lowland areas (higher percentage deciduous) and 175 ft in upland areas (primarily conifers).

Model estimates of the difference between current early August temperature conditions and system potential temperature conditions ranged from generally near 5EF difference between RM 20 and 30 to near 10EF difference near the mouth. Even under system potential conditions, however, ODEQ (2001) concluded that the Trask River would not meet the numeric temperature criteria of the water quality standard for salmonid rearing and migration in many places, particularly in the lower reaches of the watershed.

An important limitation of this analysis, however, was the assumption by ODEQ that the natural riparian stand would be uniformly vegetated with 80- to 100-year-old trees. This conflicts with our understanding of riparian vegetation under reference conditions, which likely included a mosaic of stands of different ages and species, created by periodic disturbances (Botkin et al. 1995, Reeves et al. 2002). Based on an analysis of central Coast Range riparian areas along first- to fourth-order streams that were subject to stand-replacing fires about 145 years ago, Nierenberg and Hibbs (2000) concluded that riparian areas in the Coast Range were spatially and temporally diverse prior to settlement. Conifer frequency increased with distance from the stream, and appeared limited in the near-stream zone by the competitive advantage of hardwoods and shrubs. Thus, the shade target produced in the TMDL might have resulted in average estimated shade

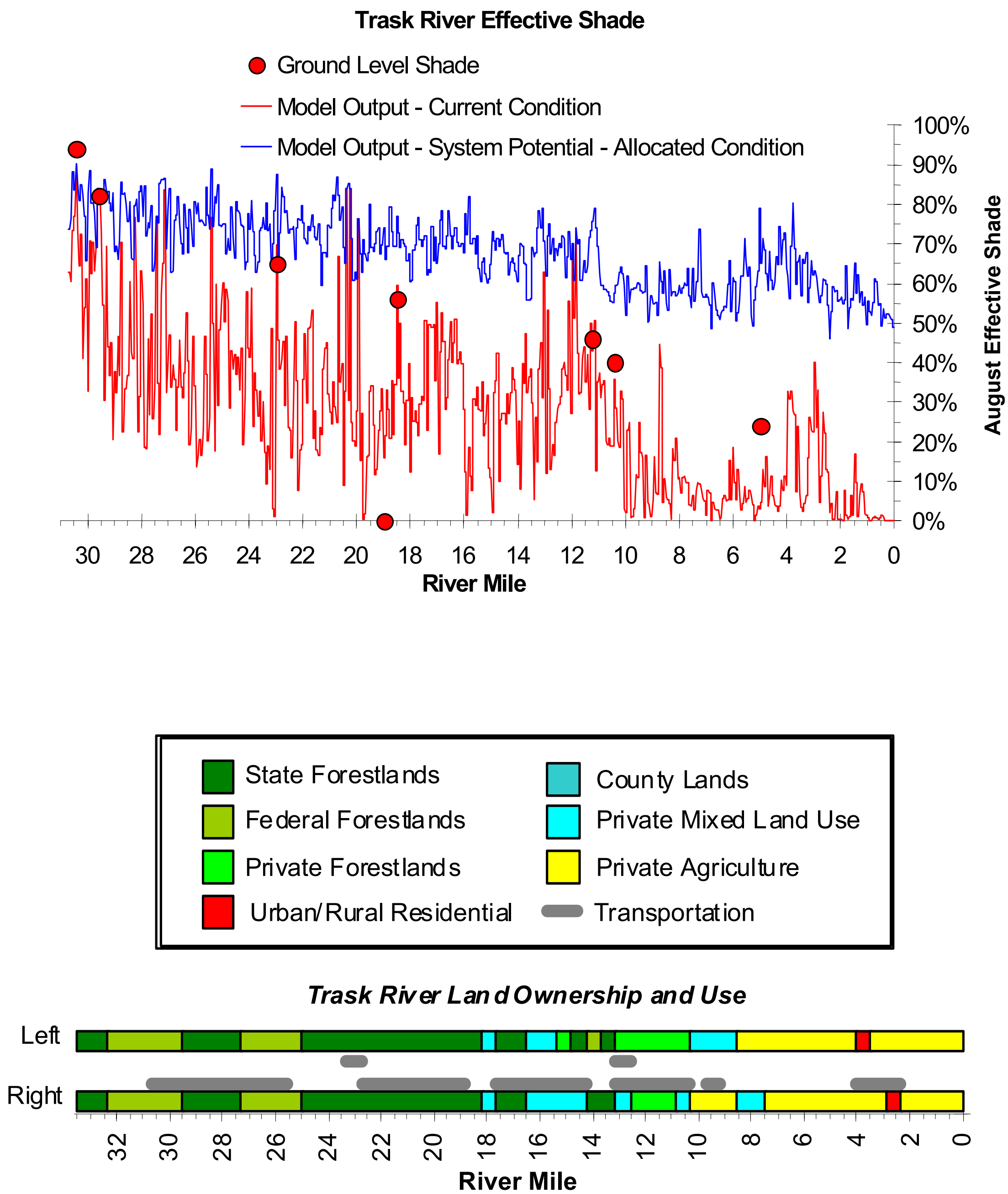

Figure 4.6. Model estimates and limited measured values (filled circles) of effective shade along the lower 30 miles of the Trask River. Effective shade was modeled as both current condition (upper data sequence) and system potential (lower data sequence). Most ODF and BLM land is upstream from river mile 18. (Source: ODEQ 2001)

levels that were higher than what actually occurred historically (ODF 2001). Nonetheless, it is also possible that an older forest having a multi-layered canopy might maintain cooler near-ground air temperatures, even if shade levels were slightly lower. Cooler air temperatures, especially within the riparian zone, would allow less heating of streamwater.

Influence of Other Factors

Other factors, some of which are related to shading, are also at least partially responsible for the observed high stream temperatures in 1998 in the mainstem reaches that were monitored. They include:

- riparian corridor (and, to a lesser extent, forest-wide) microclimate
- prevailing watershed aspect (S- and W-facing are warmer than N- and E-facing)
- prevalence and temperature of seeps, springs, and groundwater inflow
- amount of exposed rock in the stream channel (which can effectively absorb solar heat)
- reduced summer flows

In addition, even if some reaches have elevated solar radiation and stream temperature levels, an adequate supply of deep pools can provide cold-water refugia from adverse temperature conditions. Temperature differences between the stream surface and stream bottom can range up to 8EF in deep pools (Matthews et al. 1994, Nielson et al. 1994). Deep pools are less prevalent today than during reference conditions, mainly because of the reduction in LWD.

Preliminary Conclusions Regarding Stream Temperature in the Trask Watershed

Stream temperature is an important issue because a substantial portion of the Trask River system was 303(d) listed and is now under a TMDL, and because stream temperatures in some listed areas are potentially influenced by ODF and BLM management actions. Despite the importance of the issue, however, available data do not adequately reveal the spatial and temporal extent of the problem or the degree to which ODF and BLM management actions currently contribute to high stream temperatures and/or can contribute to temperature reductions. Available data do, however, rather conclusively indicate the following:

1. Stream temperatures in 1998 exceeded the salmonid migration criterion at many locations along the Trask River mainstem and in the mainstem portions of North Fork and North Fork of the North Fork.
2. Stream temperatures in 2002 did not exceed the salmonid migration criterion at any of the 16 monitored upper tributary locations.

3. Stream temperatures in both the mainstem rivers (ODEQ 2001) and upper tributaries (Falcy 2002) increase in a downstream direction. This would occur to some extent regardless of management actions, and undoubtedly occurred under reference conditions.
4. Stream temperatures increase with decreases in effective shade.
5. Effective shade is high throughout most of the upper watershed, but is lower along the mainstem reaches, especially in lowland areas.
6. Under reference conditions, effective shade was variable, in response to a mosaic of disturbed areas and late-successional and younger riparian stands. Deep pools, created by abundant LWD, provided cold-water refugia.
7. Stream temperature at the mouth of the North Fork of the Trask River is generally higher than at the mouth of the South Fork of the Trask River, especially during the warmest times of the year. The amount of shade and the prevailing hillslope aspect are probably important contributors to this observed difference.

Because stream shading is generally high in most areas on public lands, it is not clear that ODF and BLM management actions can be very effective in decreasing stream temperatures throughout the watershed. However, it is likely that 1) shading can be increased along mainstem Trask River and mainstem tributary reaches, especially in the North Fork system, and 2) such increases in shading would lead to decreased mainstem stream temperatures.

It is not clear whether the high stream temperatures documented by ODEQ in 1998 in mainstem locations were influenced by removal of riparian vegetation during the 1996 flood. It is also not clear how far up the tributary systems high temperatures typically extend. Placement of temperature monitors in past studies has not provided a sufficient sampling of temperature conditions simultaneously throughout small tributaries, mid-sized streams, and large streams to determine upstream-downstream effects or basin-wide conditions. The ODEQ data from 1998 did not examine smaller streams, and Falcy (2002) did not examine mid- or large-sized streams. Additional monitoring data would be needed to adequately evaluate the spatial and temporal patterns of high temperature values, including those above the criterion. Frequent-interval (e.g., 30 minutes) monitoring at about 40 locations during one or two summer seasons would provide the needed data.

In April, 2003, the U.S. EPA released new guidance on water temperature standards in the Pacific Northwest (U.S. EPA 2003). EPA intends that Oregon will use this guidance to revise state water temperature standards to protect native salmon and trout, particularly those listed as threatened or endangered. The most substantive changes applicable to the Trask River watershed, as compared with the current standards, include the following:

- reduction of the 64EF salmonid rearing standard to 60.8EF in core rearing areas (this may apply to portions of the middle and upper reaches of the Trask River watershed)
- adoption of a 57.2EF criterion where early stages of steelhead smoltification occur (likely applicable in April and May)

The recommended reduction in the salmonid rearing standard in core rearing areas may have a large impact on temperature compliance throughout much of the Trask River watershed.

4.1.4.2 Fecal Coliform Bacteria (FCB)

FCB concentrations in the lower Trask River were monitored, mainly during rainstorms, between 1996 and 2002. Concentrations commonly exceeded 200 cfu/100 ml during the fall, winter, and spring seasons (Table 4.9; Sullivan et al. 2002). Highest concentrations were generally found during fall rainstorms. Two storms were intensively monitored at 14 locations from RM 0 to 9.0 (Loren's Landing) along the Trask River in the fall of 1997 and spring of 1998 by Sullivan et al. (1998b). Instantaneous FCB loading estimates above the forest/agriculture interface were consistently below about 0.3×10^6 cfu/sec during the fall storm and below about 0.05×10^6 cfu/sec during the spring storm. In contrast, estimated FCB loads at many of the downriver sites, which were heavily influenced by agricultural, rural residential, and in some cases urban land uses, were frequently more than an order of magnitude higher (Sullivan et al. 1998b). Highest loads were generally achieved in the lower two miles or so of river reach. This suggests the cumulative effect of many source areas within the lowlands and/or larger individual contributions of FCB close to the bay.

Table 4.9. Percent of monitored storms having median or geomean FCB concentration in the lower Trask River higher than 200 cfu/100 ml (Sullivan et al. 2002).

Water Year	n[a]	Median	Geomean
1997	2	0	0
1998	5	80	60
1999	6	100	33
2000	5	100	100
2001	5	80	80
2002	3	67	67

[a] n is the number of storms sampled

Evaluation by Sullivan et al. (1998b) of the spatial land use patterns within the contributing drainage areas to each of the monitoring sites revealed that the FCB load contributed from portions of the Trask River watershed to the various monitored sites was not clearly or consistently correlated with any of the identified land use features. However, highest loads were often associated with high percentages of urban, rural residential, and agricultural land use. Large numbers of rural residential building clusters were also frequently associated with high FCB loads. Findings were similar when FCB loads were normalized by contributing area and by length of river segment. These findings provide strong, albeit circumstantial, evidence that the areas that frequently contribute the largest FCB loads within this watershed are primarily influenced by human activities other than, or in addition to, dairy farming. Urban areas appear to be significant contributors, as do rural residential areas. The latter, however, may also contain intensive dairy farming activities in some cases.

These results suggest that the sites which showed the largest contributions of FCB to the Trask River, at least during the storms that were intensively monitored, occurred in association with human habitation, especially the urban and rural residential areas. Highest loads were often found in the lower section of the river, which is heavily ditched and where human activity is concentrated, soils are poorly drained, and runoff potential is high. FCB loads were high throughout the lower watershed, and appear to originate from a variety of sources.

There is little that can be done by ODF or BLM to reduce bacterial contamination in the Trask River. Most of that contamination occurs below the forest/agriculture transition. Control of bacterial levels is important, however, because of impacts on the bay oyster industry and concern about human contact recreation in both the lower river and the bay. There are no data to suggest that high bacteria concentrations have an adverse impact on fish.

In some cases, wildlife contributions of FCB to streams can be substantial, and can result in FCB concentrations considerably higher than the 200 cfu/100 ml health criterion. Such high concentrations have been documented in a small tributary to the Tillamook River that has extensive beaver and elk activity (Sullivan et al. in review). Nevertheless, FCB concentrations in the mainstem Trask River are generally well below the health standard at the forest/agriculture interface and only increase to what might be considered unsafe levels in response to agricultural, residential, and urban land uses further downstream.

4.1.4.3 Total Suspended Solids (TSS)

TSS concentrations exceeding 200 mg/L in the lower Trask River were commonly observed during high-flow periods, especially during large winter storms (Figures 4.7 and 4.8). Comparison of concentrations measured for paired samples collected at approximately the same time from the forest-agriculture interface and the lower mainstem suggested that most of the TSS in the Trask River originates in the upper forested portions of the watershed (Sullivan et al. 2002). Data from the storm-based monitoring effort (Sullivan, et al. 2002) measured the cumulative flux of TSS from the forested, and a large portion of the agricultural and urban, lands in the watershed. These data, therefore, reflect variations in the sediment loading to the lower river and the bay from major erosional sources located throughout the watershed.

TSS values in the lower Trask River are less than about 20 mg/L under low discharge (< 2,000 cfs) conditions. When discharge is above about 6,000 cfs, however, TSS generally exceeds 200 mg/L. Most of the sediment that is discharged from the Trask River to Tillamook Bay is transported as TSS during flood periods. Such floods occur primarily during winter months. Thus, TSS values during winter tend to be much higher than fall or spring values (Table 4.10).

ODEQ does not list a guide concentration for TSS in rivers of the north coast region, although guidelines for TSS and/or turbidity are under consideration (Eric Nigg, ODEQ, pers. comm.,

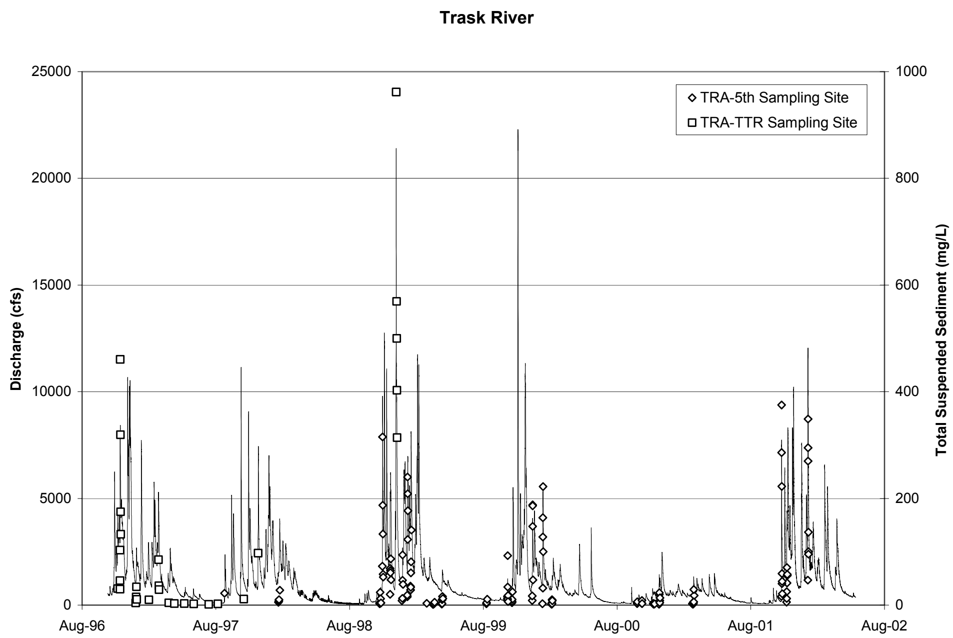

Figure 4.7. Discharge and measured values of total suspended solids in the lower Trask River throughout the period of monitoring from 1996 to 2002 (Sullivan et al. 2002).

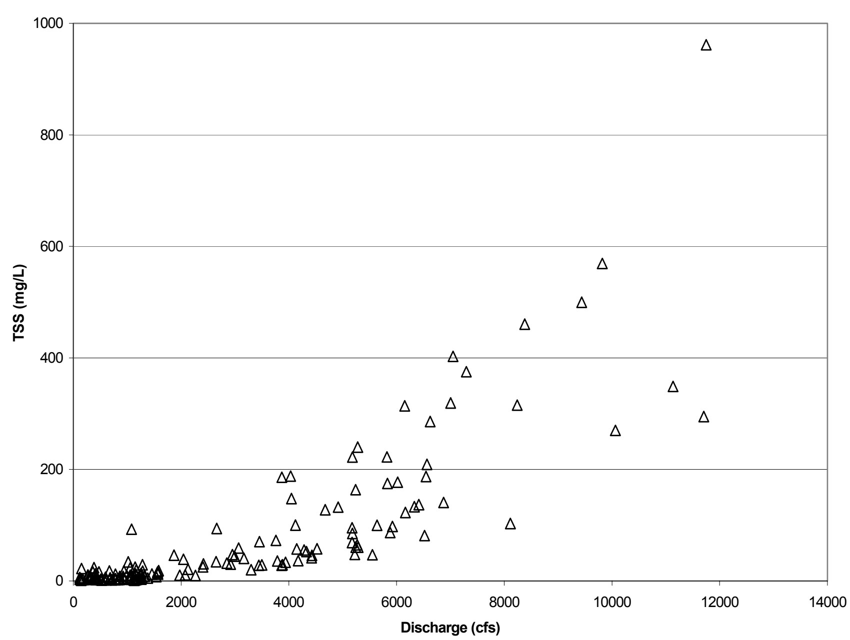

Figure 4.8. Relationship between total suspended solids and discharge for the lower Trask River, 1996-2002.

Table 4.10. FCB and TSS concentrations by season[a] in the lower Trask River, based on data collected during rainstorms between 1996 and 2002.						
	FCB (cfu/100 ml)			TSS (mg/L)		
	Fall	Winter	Spring	Fall	Winter	Spring
Number of samples	87	65	58	54	72	36
1st Quartile	205	93	111	5	18	3
Median	560	234	245	15	54	4
3rd Quartile	1153	440	788	51	152	10
[a] Fall was defined as Sept. 1 to Nov. 30, winter and Dec. 1 to Feb. 15, and spring as Feb 16 to May 31						

September 2002). Discharge-weighted storm median TSS is often above 100 mg/L in the lower Trask River during winter storms (Sullivan et al. 2002). High sediment loads constitute an important environmental concern because deposition of fine sediments can adversely impact the quality and availability of spawning gravel and can contribute to sediment accumulation in the bay. A comparison of bay bathymetric data collected in 1867, 1957, and 1995 (Bernert and Sullivan 1998) did not suggest that the bay was significantly deeper in 1867. Variance in the interpolation approach, combined with errors in the water depth measurements and inadequate documentation of the benchmarks to which the measurements were standardized, were so large as to prevent quantification of actual changes in the depth of the bay. The results were consistent, however, with an interpretation of greater depth complexity and less channelization on average in 1867.

4.1.4.4 Nutrients

Total phosphorus (TP) in the lower Trask River is strongly episodic, achieving high concentrations under high discharge conditions. Based on results of a one-year study at paired sampling locations, it appears that most of the TP in this river originates in the upper forested portions of the watershed (Sullivan et al. 1998a; Figure 4.9). Because the TP concentrations are strongly correlated with TSS (Figure 4.10), it is likely that much of the observed TP is geologic, rather than anthropogenic, in origin. Studies in neighboring watersheds have found high P levels in some sedimentary rock types (Dave Degenhardt, ODF, pers. comm., July 2003).

Concentrations of inorganic nitrogen, most of which is in the form of nitrate, are relatively low in the lower Trask River compared with rivers that are heavily influenced by urban or agricultural activities, ranging between about 0.3 and 1.1 mg N/L (Figure 4.11). Nevertheless, these concentrations exceed the U.S. EPA guidance value for total N (0.1 mg/L; U.S. EPA 2002). Most of this N originates in the upper, forested portions of the watershed (Sullivan et al. 1998a; Figure 4.12), probably from N-fixation associated with red alder and/or other N-fixing plants. The N concentration data exhibit strong seasonality, with highest concentrations during winter and lowest concentrations during summer (Figure 4.13). This pattern is likely due largely to biological uptake of N from both terrestrial and aquatic watershed compartments during the summer growing season and flushing of nitrate from the soil to the stream system during winter months.

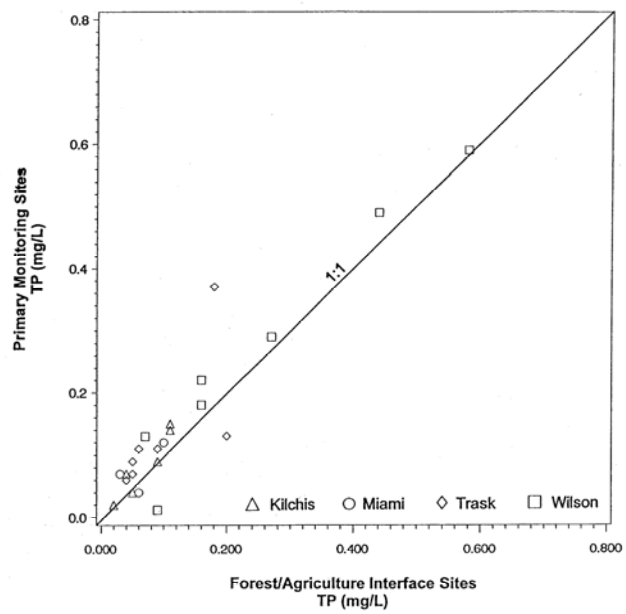

Figure 4.9. Results of paired sample analyses for total phosphorus (TP; mg/L) at the primary site and its respective forest/agriculture interface site for the four rivers in which both types of samples were collected. A 1:1 line is provided for reference. These data suggest that TP concentrations at the forest/agriculture interfaces are generally nearly as high as TP concentrations near the mouth of each of the rivers, respectively. Thus, most TP originates from the upper, forested portions of the watersheds (Sullivan et al. 1998a).

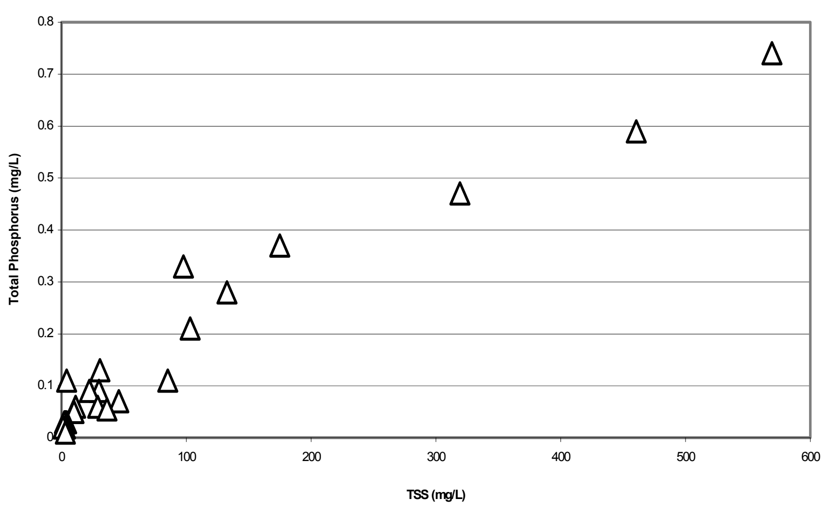

Figure 4.10. Measured values of total phosphorus versus total suspended solids (TSS) for the lower Trask River, 1996-2002.

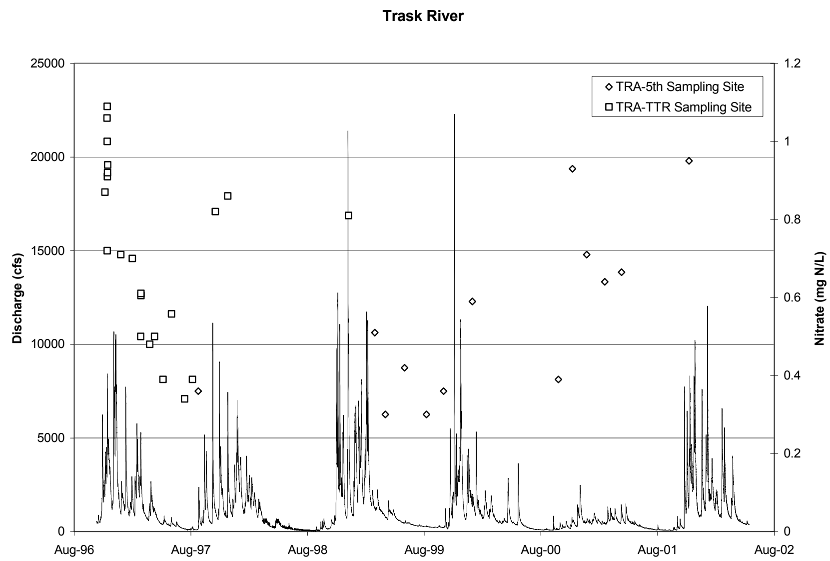

Figure 4.11. Discharge and measured values of nitrate for the lower Trask River (Sullivan et al. 2002).

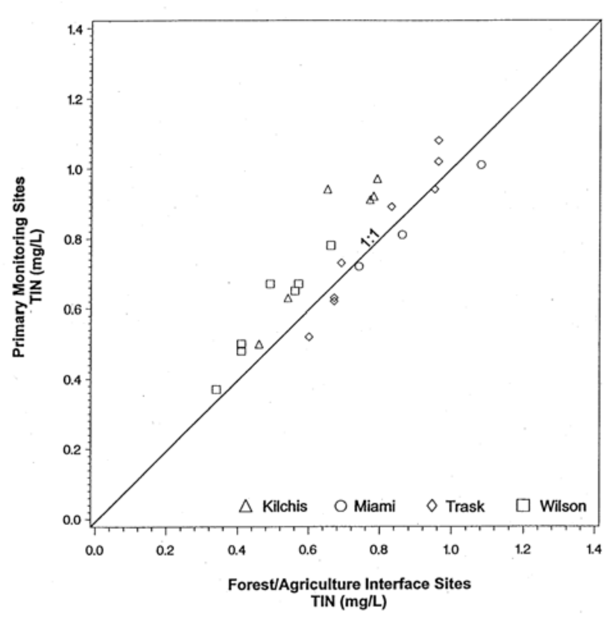

Figure 4.12. Results of paired sample analyses for total inorganic nitrogen (TIN; NO_3-N + NH_4-N; mg/L) at the primary site and its respective forest/agriculture interface site for the four Tillamook Basin rivers in which both types of samples were collected. A 1:1 line is provided for reference (Sullivan et al. 1998a).

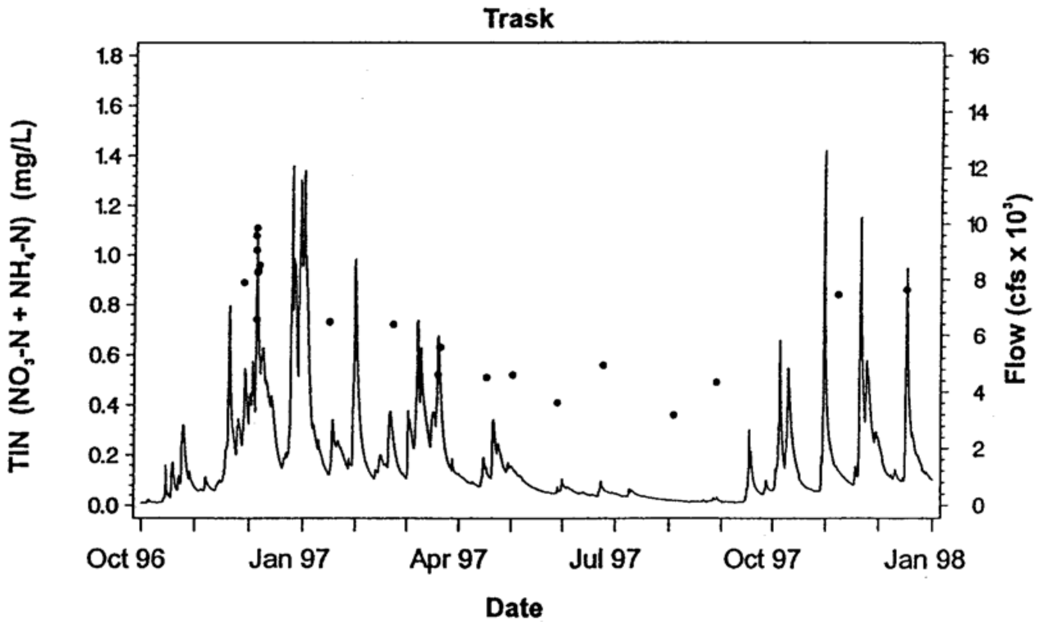

Figure 4.13. Concentration of inorganic N (TIN; mg/L) and river flow (cfs x 10^3) at the primary monitoring site on each river over a one-year period (Sullivan et al. 1998a).

Available data suggest that the concentration of nitrate in the Trask River has been increasing in recent decades (Figure 3.11). We have found similar results in the Miami and Necanicum River watersheds (Snyder et al. 2001, 2002). It is likely that this pattern is attributable to the gradual growth and development of riparian alder stands, with consequent increase in nitrogen fixation.

Eutrophication (nutrient enrichment) is a concern in most estuaries in the United States and will continue to be a concern as coastal populations increase (Day et al. 1989). Tillamook Bay has been classified as moderate to high in the National Oceanic and Atmospheric Administration's (NOAA) estuary eutrophication classification (NOAA 1996). Inorganic nitrogen loads to Tillamook Bay are highly dependent on flow and are therefore much higher during winter than summer. Biological uptake of N in the aquatic, and perhaps terrestrial, environment during summer is likely an additional important determinant of N dynamics in the watershed. Overall, the concentration of N in the Trask River is not especially high compared with rivers elsewhere in Oregon. For example, the median concentration of NO_3-N in the Willamette Basin during the period 1993-1995 was 1.1 mg/L (n=289), with 10% of the samples above 5.9 mg/L (Rinella and Janet 1998). In contrast, flow-weighted average concentration in the lower Trask River in 1997 was 0.8 mg/L and concentrations were always less than 1.3 mg/L (Sullivan et al. 1998a). Nevertheless, in view of the moderately high productivity of Tillamook Bay, and the fact that estuaries are generally N-limited, any enhanced N loading from the watershed to the bay in response to management activities should be avoided.

4.1.4.5 Dissolved Oxygen

Dissolved oxygen concentrations below the 11 mg/L salmonid spawning standard have been found throughout the watershed (Figure 3.5), but such values are likely associated with warm waters during late summer and would therefore not be expected to impact fish spawning. No salmonid spawning occurs in the Trask River watershed in July or August when stream temperatures are warmest. Dissolved oxygen concentrations below the salmonid rearing criterion (8 mg/L) have also been found, almost exclusively in the sloughs in the lower watershed. High temperatures, and perhaps high nutrient and organic matter concentrations, in the sloughs are the likely causes of low dissolved oxygen in these areas.

4.1.4.6 Management Effects on Water Quality

Under reference conditions, riparian forests included a diversity of conditions, including a broad distribution of age-classes and species, maintained by natural disturbances such as fire, floods, landslides, windthrow, and disease. Zones of mature conifer forest were interspersed with hardwood stands and canopy gaps created by localized disturbance. In-stream structural complexity fostered more and deeper pools, interspersed with riffle and drop areas, providing additional oxygenation of streamwater and refugia from periodic high temperatures. Along the mainstem of the Trask River, riparian forests were removed by forestry and agricultural practices, and in the uplands by Tillamook Burn fires and subsequent salvage logging. In part because there was no allowance for riparian buffer strips prior to about 1980, land use activities contributed to greater exposure of the stream to sunlight, causing higher temperature and lower dissolved oxygen levels. Such effects have been reversed by subsequent reforestation. Increased erosion contributed to higher turbidity and suspended solids. Roads, especially those that were poorly constructed in conjunction with salvage operations in the mid-1900s, have contributed, and probably continue to contribute, sediment to streams. Sediment delivery is more likely where roads parallel or cross the stream channel.

Agriculture, rural residential housing, and urban development have contributed to water quality concerns and problems in the Lower Trask River subwatershed. Cultivated soils are more susceptible to erosion. In addition, manure spreading on pasture lands, poorly-functioning septic systems, urban storm drains, and point sources such as sewage treatment plants contribute fecal bacteria and nutrients to the lower Trask River. The filling, draining, ditching, and disconnection of wetlands have reduced their ability to filter pollutants (including bacteria, sediments, nutrients, toxic compounds) from runoff.

The limited available data suggest that water quality may have improved for most parameters in recent decades. In particular, conditions for temperature, fecal bacteria, and phosphorus seem to show signs of improvement, whereas nitrogen concentrations seem to be increasing (Figure 3.17). These improvements in temperature, bacteria, and P, if they are real, may be due, in part, to implementation of BMPs in forestry and agriculture.

It is unlikely that changes in land management practices would have an appreciable effect on P concentrations in the Trask River during low flow summer conditions. Most of the current P load is associated with large winter storm events and is likely derived from erosion in the upper watershed. It is unknown to what extent the high winter P load might influence summer concentrations, but such an influence is probably most pronounced in the lower reaches of the mainstem Trask River and in Tillamook Bay, where fine sediments accumulate. Manure spreading activities, animals grazing in riparian areas, and inadequate septic systems provide additional nonpoint sources of P. Infrequent summer rainstorms provide an important mechanism for transporting P from such sources to the stream channel. Implementation of BMPs in agricultural and rural settings will help to reduce P loading, as will erosion control efforts throughout the watershed. However, such actions would not be expected to have a large impact on P dynamics within the Trask River watershed, especially in the short term.

Similarly, changes in land management practices would not be expected to alter streamwater N concentrations to an appreciable extent, although BMPs to reduce livestock and septic system contributions would be helpful. Over the long term, increasing the presence of conifers throughout some of the riparian zones in the watershed might be expected to have the greatest impact, but such an effect would take decades to develop.

4.1.4.7 Forest Chemicals

Pesticide application methods are designed to minimize the entry of pesticide residue into the stream system, but this issue has not been examined in any detail in the watershed. It is also possible that fertilizer application to forest stands has constituted an episodic source of N to the river. There are no data suggesting that the use of forest chemicals has adversely impacted aquatic ecosystems in the Trask River watershed.

4.1.4.8 Streams on the Oregon 303(d) Water Quality Limited List.

Stream placement on the 303(d) list can generally be attributed to management practices, both past and current, within the watershed. Most 303(d) listings within the Trask River watershed are in the lower river reaches, sloughs, and lowland tributary streams (Table 3.10). Causes for these listings are generally outside the control of ODF or BLM management, and most commonly include such factors as fecal bacteria and dissolved oxygen.

Temperature listings have been more widespread, and included the mainstem Trask River, North Fork Trask River, and North Fork of the North Fork Trask River. There were 101 miles of temperature-limited stream length in the Tillamook Basin, one-third of which was in the Trask River watershed. The TMDL was approved for these areas. The 1998 ODEQ 303(d) list included 30.7 miles of the Trask River listed as impaired for water temperature. Of that total, 62% was along the lower main stem (mouth to South Fork), 23% was the North Fork of the North Fork (mouth to headwaters), and the remainder was the lower section of the North Fork (mouth to Bark Shanty Creek). The mainstem has exceeded the 55EF spawning and rearing criterion during the period June through October, and the 64EF rearing and migration criterion between mid-June and mid-September. ODF and BLM management can have influence on these temperature listings, in part because these agencies control appreciable percentages of the streamside areas in, and upstream from, these river reaches. There are no data, however, to

suggest widespread exceedences of the temperature criterion for salmonid migration in most upper tributary reaches. Additional monitoring is needed.

Temperature-sensitive beneficial uses in the Trask River include:

- anadromous fish passage
- salmonid fish spawning and rearing
- resident fish and aquatic life

To accomplish the goals identified in OAR 340-041-120 (11), no measurable streamwater temperature increase resulting from anthropogenic activities is permitted in the Trask River, unless specifically allowed under an ODEQ-approved management plan.

There are also two reaches listed for flow modification: East Fork of South Fork Trask River and North Fork Trask River. In addition, the mainstem Trask River is listed for habitat modification. It is not likely that current or future ODF and/or BLM management would play an important role in these listings other than future contribution of LWD to the system, although historic logging activities in the uplands undoubtedly had adverse impacts on habitat quality in the mainstem Trask River.

4.1.4.9 Effects of Water Quality on Recreation

Current water quality limits the extent to which the Trask River watershed provides recreational opportunities within lands managed by ODF and BLM. This limitation is entirely indirect, via the impacts of high water temperature on cold-water fishing opportunities. In the lower watershed, high bacterial contamination and eutrophication limit the desirability and public safety of in-stream recreational contact such as swimming and wading. Strategies to enhance stream shading and restore riparian functionality in mainstem reaches throughout the watershed and to reduce bacterial and nutrient contamination in the lower river and sloughs will create conditions more favorable for in-stream recreational opportunities.

Fecal coliform bacteria and *E. coli* are frequently used as indicators of fecal inputs to stream systems. High FCB (and associated virus) levels can cause disease and restrict the beneficial uses of the water, especially for drinking water and human contact recreation. Most of the bacteria data available for the Trask River are for FCB, and therefore this is the parameter of focus for this report.

Results of a recent study of FCB source areas along the Lower Trask River suggested that the most important sources of FCB to the Trask River mainstem during storm events included the following areas (Sullivan et al. 2003):

- below the STP outflow – This area receives effluent from the City of Tillamook's STP and also receives stormwater runoff from an adjacent residential neighborhood and from the western portion of the city.
- below Holden Creek confluence – Bacterial contamination of Holden Creek is believed to be associated with failing private septic systems, runoff from a lumber mill yard, and possibly drainage from adjacent dairy farms.
- distributed sources along lower Trask River – A variety of stormwater drain pipes from urban and residential areas in and around Tillamook and drain pipes from adjacent dairy pastures are believed to constitute important FCB source areas within the lowest river mile of the mainstem Trask River.

4.1.5 AQUATIC SPECIES AND HABITAT ISSUES

4.1.5.1 Aquatic Habitat

The major focus of habitat quality issues within the Trask River watershed concerns anadromous salmonid species, in particular the influence of habitat quality on coho salmon (federally Threatened), steelhead (Candidate for federal listing), coastal cutthroat trout (Species of Concern), and chum salmon (ODFW Critical Status). Other important fish species include chinook salmon (listing not warranted) and Pacific lamprey (Species of Concern). Habitat quality for non-fish species is also important. Amphibian distributions extend to portions of the upper watershed, above the limit of fish distribution. Therefore, managing for fish habitat will not necessarily protect or improve all amphibian habitat.

The characteristics that define habitat suitability differ from species to species and from habitat to habitat. In general, parameters of habitat suitability reflect the needs of a species for food, water, cover, reproduction, and social interactions (Young and Sanzone 2002). Such needs are fulfilled through aspects of the physical, chemical, and biological environment, including water temperature, dissolved oxygen, flow velocity, substrate type, and the presence of predator, prey, and competitor species.

Appropriate habitat conditions in upland streams (i.e., those that will maintain watershed function) would include adequate shading of the stream channel, an abundance of LWD and deep pools, intact riparian vegetation that includes large-diameter conifer trees, adequate in-stream gravel conditions, an absence of passage barriers, and the availability of off-channel refugia. In lowland locations, additional important habitat conditions would include stream sinuosity, connection to estuarine and freshwater wetlands, floodplain functionality, and intact riparian vegetation. Past management practices have resulted in conditions that seldom meet these ideals.

In-stream LWD conditions were rated as 100% undesirable in the Lower Trask, North Fork of North Fork, and Middle Fork of the North Fork subwatersheds, and only slightly better in the Upper Trask subwatershed. Conditions were substantially better in the Elkhorn Creek and South Fork subwatersheds, especially the East Fork of the South Fork subwatershed (Figure 3.22).

LWD recruitment potential was rated as undesirable throughout the watershed, based on ODFW data illustrating the scarcity of conifers larger than 20 inches dbh.

The best salmonid spawning and rearing habitat in the watershed appears to be located in the East Fork of the South Fork and in Elkhorn Creek. Due largely to the Tillamook Burn and salvage logging operations, the quality of much of this (best available) habitat is diminished from reference conditions. In particular, habitat complexity has been reduced in association with LWD removal, inadequate LWD recruitment, increased sedimentation, reduced pool frequency and depth, and the general homogeneity of riparian vegetation. The North Fork Trask subwatershed appears to be particularly limited by poor shade conditions along the mainstem, and the Middle Fork of the North Fork by poor current LWD conditions (Table 4.11). In-stream gravel conditions are best in the East Fork of the South Fork and Elkhorn Creek subwatersheds (Table 4.12).

Management actions to improve salmonid habitat should probably focus primarily on enhancing LWD conditions, improving LWD recruitment potential, and reducing stream mainstem temperatures. Other important activities would likely include identifying and removing fish passage barriers, and reducing erosion. Actions to improve conditions for one species will usually improve conditions for many other species as well. The most dramatic short- to moderate-term improvements in stream shade can be realized through targeted conifer planting and conifer release efforts focused on the mainstem Trask River and North Fork system (including the North Fork, North Fork of the North Fork, and Middle Fork of the North Fork subwatersheds). Benefits to fish may, however, be best realized through efforts focused in and around portions of the highest quality salmonid habitat, which is located in the South Fork system and Elkhorn Creek. Given the length of the mainstem streams lacking large riparian conifers and exhibiting low shading, proportionately greater benefit can be realized by focusing most planting efforts on south and west banks (i.e., plant twice as much stream length, but only on one side). However, where bank erosion is evident along north and east streambanks, these areas should also be planted. LWD emplacement can also be an effective tool for improving LWD conditions in the short term. However, LWD emplacement is expensive and, given a finite funding level, many more miles of stream can be treated with riparian planting and conifer release, as opposed to LWD emplacement.

The East Fork of the South Fork and Elkhorn Creek are believed to provide the best overall salmonid habitat currently. These subwatersheds are notable in terms of generally having high shade, LWD pieces, LWD volume, and gravel in riffles, compared with other subwatersheds (Tables 4.11 and 4.12).

4.1.5.2 Fish

In addition to their fisheries and intrinsic values, the anadromous salmonids in the Trask River watershed function as indicators of stream and estuary ecosystem condition. Habitat quality and quantity are probably to some extent limiting for all of the salmonid species. Anadromous and resident salmonid species inhabit the Trask River system year-round (Figure 4.14; Plates 6, 7, and 8). Rearing occurs during most or all months by some or all salmonid species present except

Table 4.11. Fish use and habitat condition summary, by subwatershed.								
	Stream Miles	Miles Surveyed	Fish Use	% RA2 LWD Riparian Recruitment (ODF)	ODFW Riparian Shade	# LWD PIECES	LWD VOL	KEY LWD
EF of SF Trask	177	35	FC, SC, WS, SS, Coho	17	94	17	29	0
Elkhorn	105	10	FC, WS, SS, Coho	29	92	19	37	1
Lower Trask	89	11	FC, SC, WS, SS, Coho, Chum	9	32	2	3	0
MF of NF Trask	81	6	FC, SC, WS, SS, Coho	31	82	0	0	0
NF of NF Trask	77	4	FC, WS, SS, Coho	17	77	0	0	0
NF Trask	193	17	FC, SC, WS, SS, Coho	6	79	17	42	2
SF Trask	151	14	FC, SC, WS, SS, Coho	9	93	14	21	0
Upper Trask	197	19	FC, SC, WS, SS, Coho, Chum	4	66	8	24	0

Table 4.12. Fish use and in-stream habitat condition summary, by subwatershed.							
	Stream Miles	Fish Use	Pool Frequency[a]	Percent Pools[b]	Residual Pool Depth (m)	Gravel in Riffles (% area)	Rating of Gravel in Riffles
EF of SF Trask	177	FC, SC, WS, SS, Coho	57	10	0	37	Good
Elkhorn	105	FC, WS, SS, Coho	10	26	1	38	Good
Lower Trask	89	FC, SC, WS, SS, Coho, Chum	21	25	2	25	Fair
MF of NF Trask	81	FC, SC, WS, SS, Coho	5	44	0	23	Fair
NF of NF Trask	77	FC, WS, SS, Coho	6	37	1	19	Fair
NF Trask	193	FC, SC, WS, SS, Coho	8	28	1	21	Fair
SF Trask	151	FC, SC, WS, SS, Coho	14	19	1	32	Fair
Upper Trask	197	FC, SC, WS, SS, Coho, Chum	14	22	1	28	Fair

[a] Pool frequency was calibrated to stream size
[b] Percent of pools was expressed as the percent of the channel area in pools

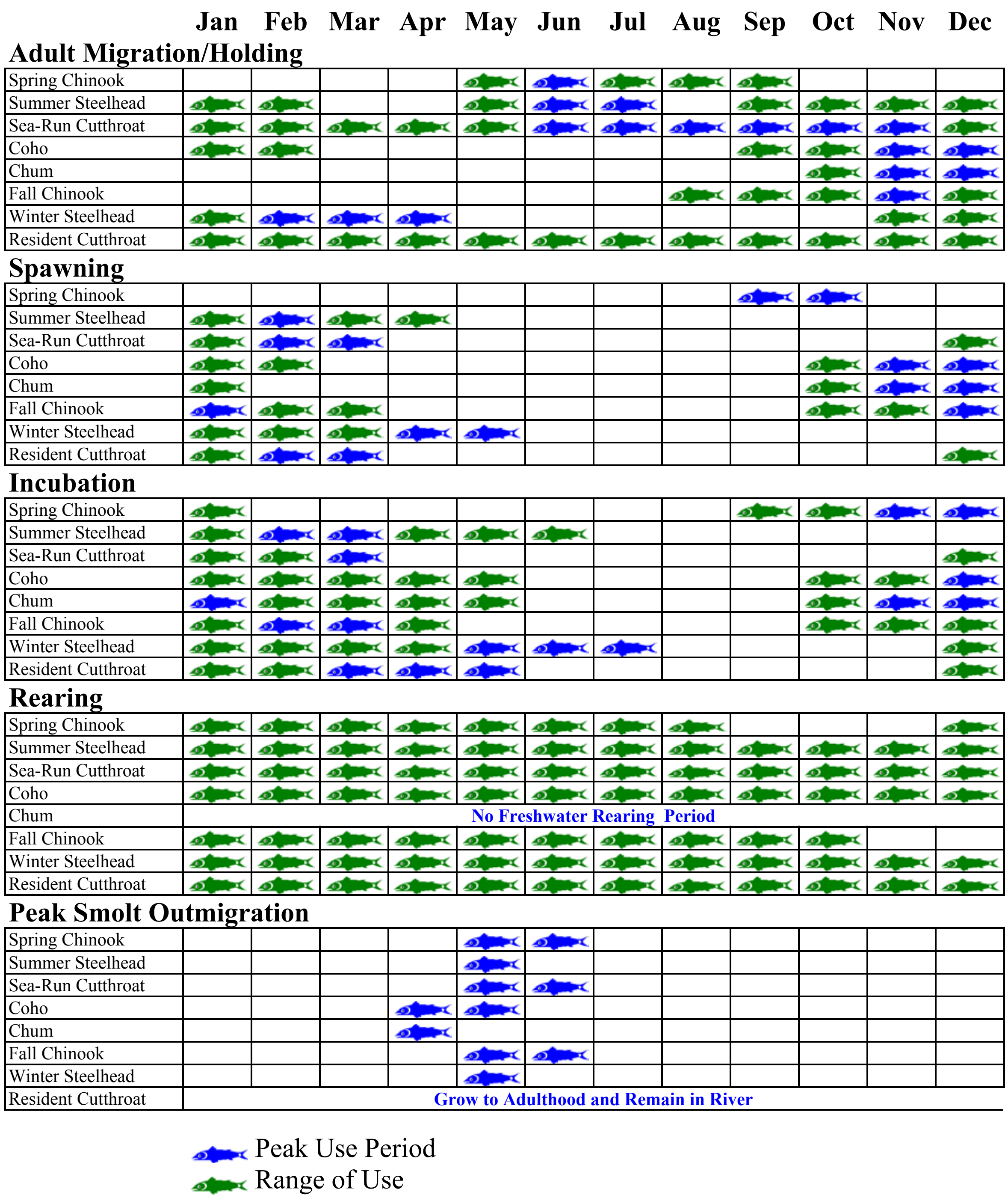

Figure 4.14. Salmonid use of the Trask River system. (Source: ODEQ 2001)

chum salmon, which does not rear in freshwater. Peak use times vary by species, but peak use occurs for at least one salmonid species during every month of the year.

Mainstem sections of the Trask River are used as migration corridors by all species of anadromous salmonids present. In addition, chum salmon use much of the mainstem within the Lower Trask River subwatershed and into the Upper Trask River subwatershed for spawning (Plate 6). Coho spawning and rearing occur primarily in the mainstem sections of the SouthFork, East Fork of the South Fork, and North Fork subwatersheds. Chinook salmon and steelhead use almost the entire mainstem (as well as much of the upper watershed) for spawning and rearing (Plate 7). The mainstem exhibited a greater prevalence of LWD during the reference period, which implies more extensive pool development. Stream shading in the Lower Trask was substantially better prior to Euro-American settlement, and off-channel refugia were abundant. Channelization and disconnection of the mainstem from much of its floodplain and estuarine wetlands have contributed to the loss of extensive salmonid rearing habitat for all anadromous species. Increased water temperature and habitat degradation in the lower river have also likely been detrimental to Pacific lamprey, which have similar habitat requirements to salmonids. Larval Pacific lamprey probably utilized off-channel areas extensively, and this habitat has been dramatically reduced.

Migration of salmonids has been impeded by roads and culverts in some locations. The degree of impedance is not known. Migration may also be inhibited by low-flow conditions on occasion, a problem that could be exacerbated by water diversions. Unscreened diversions may pose an additional hazard to migrating and rearing fish.

4.1.6 WETLANDS: MANAGEMENT IMPACTS

4.1.6.1 Wetland Quantity and Quality

Wetlands are, and historically were, located mainly in the Lower Trask River subwatershed. Many of these wetlands are, and were, estuarine, and provide(d) important rearing habitat for anadromous fish and other species of aquatic biota. The National Wetlands Inventory (NWI) shows 962 acres of wetland in the watershed, but NWI data are only available for the lower watershed sections.

Human activities have reduced the extent of both estuarine and palustrine wetlands within the watershed by an appreciable, but unquantified, amount. River channelization, construction of dikes and levees, tidegate installation, and ditching have collectively converted extensive estuarine wetland areas to pastures and urban areas. In addition, much of the remaining wetland area has lost some of its connection to the river system. Palustrine wetlands in the lowlands have been converted to agricultural land through channelization, ditching, and installation of tile drains. Beaver trapping has reduced the density of smaller wetlands throughout the watershed. Livestock grazing in wetlands and the introduction of non-native plant species have also resulted in wetland degradation, especially in the lower watershed.

Although wetlands are not common in forested portions of the Trask River watershed, those wetlands that do occur and are hydrologically connected to the stream system can provide important salmonid rearing habitat and off-channel refugia from high-flow conditions. Protection and enhancement of palustrine wetlands throughout the watershed could be an effective management goal. Estuarine wetland management is not under the direct control of ODF or BLM. However, estuarine wetlands provide critical habitat for supporting salmonid life cycles, and estuarine wetland protection and restoration may provide good opportunities for outreach and collaboration with other watershed stakeholders.

4.1.6.2 Impacts of Wetland Changes Upon Species

Loss of wetland habitat has likely reduced the abundance of wetland-dependent species within the watershed, but quantitative data are not available. It is assumed, for example, that the abundances of many amphibians, waterfowl, and fish have been reduced as a consequence of the historic loss and degradation of wetlands. For salmonid fish, it is possible that the extensive loss of lowland rearing areas has had a significant impact on potential population size for several species. Off-stream wetlands formerly provided refugia from high-flow conditions, as well as abundant food sources and shelter. Riparian habitat degradation, with the accompanying loss of side channels, has further exacerbated the adverse impacts associated with wetlands loss, degradation, and disconnection.

4.2 TERRESTRIAL

4.2.1 ROAD-RELATED ISSUES

Roads provide many useful benefits, including access for timber extraction, fire suppression, and recreation. However, road construction can result in a high level of disturbance to the forest ecosystem, potentially affecting the hydrology, soil stability, fish passage, and downstream transport of material through the stream network. Road construction can expose bare soil on cutslopes, fillslopes, and ditches, which is vulnerable to erosion until it becomes vegetated. In order to withstand traffic by log trucks and heavy vehicles, a compacted, impervious surface is created, and in some cases runoff is re-directed along roadside ditches. Roads have long been the focus of concern regarding erosion and sedimentation of streams. However, the extent of impact is dependent on many factors, including road location, proximity to stream, slope, and construction techniques. Ridge top roads on slopes less than 50% generally have little impact on streams. Valley bottom, and mid-slope roads, especially those on steep slopes or near streams, can have great effects on sediment delivery to streams.

In the upland, forested portion of the Trask watershed, the majority of the roads were constructed for salvage logging purposes after the Tillamook Burn. Older roads such as these (i.e. constructed prior to 1960) have been found to contribute more erosion by landslides than more recently constructed roads because of poor location, fill design, and drainage (Skaugset and

Wemple 1999). Road-related landslides and debris flows were frequent during large storm events subsequent to the Tillamook Burn, delivering large quantities of sediment to the streams.

However, road construction practices have changed significantly over the past 30 years. Improved road location, design, drainage and maintenance practices have all served to address problems associated with roads. Full bench and end haul construction practices on steep slopes prevent fillslope landslides, and frequent cross-drain culverts divert road surface runoff before it reaches a stream channel. In addition to improvements in the construction and management of roads, other changes in forest management practices have served to reduce the impacts of roads. In particular, changes in timber harvesting practices, such as the use of long-span high-lift cable systems has reduced the need for roads, resulting in a reduction in road density. Protection zones around streams and riparian buffer strips have served to mitigate negative road impacts.

Nonetheless, recent studies have confirmed that even contemporary road construction practices contribute increased sediment from debris slides and debris flows (Skaugset and Wemple 1999). Continued improvement of the road system, including closure of unnecessary or problematic road segments, replacement of undersized culverts, and ongoing maintenance, will be necessary to minimize the impacts of roads on sediment delivery to streams.

The ODF Forest Roads Manual provides extensive guidance on the location, siting, and construction of roads and road drainage structures. The following sections provide a summary of the road design criteria presented in the manual.

4.2.1.1 Considerations Related to Road Design

Effective road construction should disperse water from the road, minimizing erosion and direct discharge of runoff to streams. Drainage structures such as dips, water bars and cross-drain culverts should be located to avoid stream crossings, and ditch relief culverts should be placed at appropriate distances to eliminate direct connection between road runoff and streams. ODF guidelines specify that road grades will be kept between 2% and 18% whenever possible. A minimum of 2% road grade facilitates water drainage from the road prism. Road grades above 15% should be avoided, except where needed to keep roads off steep slopes or away from streams. Where steep grades are necessary, extra consideration is required of drainage structures, including culvert spacing, water bars, water dips, road grade reversals, and road surface maintenance.

Stream crossing structures must be designed to protect aquatic and riparian conditions and provide fish passage. Road/stream crossings create added risk of erosional inputs to the stream and potential migratory hazards to anadromous fish. Where culverts are too small, or become blocked, there is added risk of road washouts, contributing to further erosion and sedimentation problems. Streams should be left in their natural channels, and not diverted to crossing structures; stream crossing structures must be sized to allow for a 50-year storm. Safety features should be utilized in case the structure becomes plugged or fails, including lowered fill heights, dips in the road, armored fills, and overflow culverts.

4.2.1.2 Siting of Roads

In general, roads should be located in areas that minimize the risks of blocking fish passage and contributing sediment to the stream system. Wherever possible, steep slopes, slide areas, wetlands, sensitive areas, and road locations parallel to streams should be avoided. Roads near streams are more likely to deliver sediment to streams, and also occupy important space in the riparian zone. Whenever possible, duplication of roads should be avoided, and existing roads should be used.

A useful consideration for road siting is road slope-position, such as whether a road is sited on a ridgetop, midslope, or valley-bottom location. Ridgetop roads have the least likelihood of contributing sediment to the stream system, because they are usually farthest from streams, and on areas of more gentle slope. Midslope roads are more frequently located on steep slopes than ridgetop and valley roads, and have a high probability of interacting with sediment movement processes, either by initiating landslides, being washed-out by debris flows, or blocking the path of a debris flow. Valley roads more commonly block debris flows, or are washed-out, contributing sediment to a stream (Jones et al. 2000). Valley roads also are the most likely to impede fish passage. Among inventoried ODF roads in the Trask River watershed, the majority of roads were midslope roads; in every subwatershed except the Lower Trask more than half of the roads were located on midslope positions (Table 3.22). Future siting of roads should avoid valley and midslope areas wherever possible, and midslope and valley roads should receive priority for decommissioning.

The highest risk for slope failures and erosion associated with roads occurs in steep lands underlain by geology that gives rise to unstable soils. The locations of steep areas in the Trask watershed are shown on Plate 2. Slope failures create opportunities for enhanced sediment input to streams, especially where roads are located both on steep terrain and in close proximity to a stream. Such roads are concentrated most heavily in the North Fork, North Fork of the North Fork, and Upper Trask subwatersheds (Table 4.5).

federal standards, State Forest Practices Act, and BMPs all agree on the basic principles of minimizing roads and landings, avoiding disruption of natural hydrological flow paths, and adopting guidelines for sidecasting and measures to prevent introduction of sediment to streams. Additional guidelines specify culvert, bridge and stream crossing design, and prioritization of road siting based on current and potential future impacts to ecological value of the affected resources. Road design methods such as outsloping road surfaces, routing runoff away from potentially unstable channels, fills and hillslopes are generally agreed on.

4.2.1.3 Road Construction

Road width should be minimized to meet the needs of the anticipated use. Where possible, roads should be constructed with a balanced cut-and-fill cross-section. Stable fills should be created by using compaction, buttressing, subsurface draining, rock facing, or other effective means of stabilization. On steep slopes and/or high-risk areas, full-bench construction and end-hauling of excess material is required.

According to the ODF Forest Roads Manual, specifications to minimize impacts during construction include the need to:

- Limit construction activities to drier periods of the year, especially any activity involving exposed soil, such as grubbing, excavation or grading.
- Curtail activities on exposed soil during rain events, even when they occur during the dry season.
- Establish and maintain drainage throughout the construction phase.
- Take precautions to prevent siltation when rain is likely to occur. Precautions include installation of hay bales, filter cloth, or other measures placed in ditch lines or other strategic locations to filter runoff water.
- When in-stream work is necessary, it should be accomplished during seasonal periods recommended by a fish biologist. A written plan is required by the Oregon Forest Practices Act and must be approved before working in a Type F (fish bearing) or Type D (domestic use) stream.
- Soils exposed by road construction or improvement that could enter streams will be seeded with grass or other vegetation to prevent erosion. These areas will be seeded at a time conducive to growing new grass and prior to the start of the wet season. Spring and fall periods are generally preferred for grass seeding.

4.2.1.4 Ditches

Ditches can potentially expand the stream network during storms. They can alter both the sediment load and the timing of delivery of runoff to the stream. Proper drainage of roads is important to minimize the adverse impacts of roads on water quality and aquatic habitat.

Ditch construction practices that reduce erosion and dissipate energy include lining the ditch with irregularly shaped rocks, and constructing the ditch with a rounded bottom to prevent sediment sloughing from the walls. Frequent cross-drain culverts can help to prevent excessive contribution of runoff to streams, as well as to minimize the discharge of water below cross-drain culvert outlets.

Proper maintenance of ditches is crucial to reducing erosion and sediment delivery to streams and preventing road-related landslides. Road drainage was associated with half of the debris flows initiated from roads in a study of the road-related slides that followed the February, 1996 storm (Robison et al. 1999).

4.2.1.5 Road Closure

Decommissioning roads can help to reduce the negative impacts of roads on adjacent streams, in addition to reducing maintenance costs. At the present time, ODF is decommissioning roads at twice the rate that they are being constructed (Tony Klosterman, ODF, pers. comm. May 2003).

According to the ODF Forest Roads Manual, roads deemed unnecessary for forest management should be closed. Furthermore, roads should be closed and stabilized if they are presently causing, or are likely to cause, serious future erosion; are near fish-bearing streams; or have excessively high maintenance costs. Additionally, roads on midslope positions should be considered for closure if they are not needed. Stabilization of closed roads can include measures such as waterbar installation, removal of sidecast material, culvert removal, and planting of native grasses and other plants.

4.2.2 RIPARIAN HABITAT: MANAGEMENT IMPACTS

The quality of riparian habitat has declined in comparison with reference conditions. Historical timber harvesting and agricultural practices involved removing essentially all of the riparian forest, up to the stream channel. In contrast, more recent forest practices provide for leaving a riparian buffer along the streams. There are currently no regulations that require trees along streams in agricultural lands, but riparian fencing and planting efforts have become more widespread in the lower watershed in recent years.

One of the most effective measures ODF and BLM can take to enhance the overall health of the Trask River watershed is improvement of riparian and associated in-stream habitat conditions. Habitat degradation associated with historic land management and fire occurrence is linked to current problems related to the scarcity of snags and down logs, high stream temperature, erosion, sedimentation, and nitrogen and phosphorus enrichment. Although current forest practices are much more protective of riparian condition than were practices of the past, residual problems remain. In order to maintain watershed function and support healthy populations of salmonid fish, riparian forests should include a greater component of large conifers, including snags and down logs. Riparian plant species diversity and habitat complexity should also be increased.

It will take many decades to restore the historical diversity of riparian conditions, especially the late-successional riparian characteristics needed to maintain watershed function. Therefore, high priority should be placed on preserving areas that currently provide acceptable habitat for riparian-dependent species. Such areas should be managed to further promote the development of desirable features, including large conifers, down logs, snags, and high species diversity. This does not mean that all riparian areas should be converted to late-successional conifer forest. Rather, management should strive for a mosaic of conditions, and that mosaic should include a substantial component of late-successional conifer forest.

The angle of the sun at noon in the southern sky in the Trask River watershed during the growing season ranges from near 50° in April and September to above 60° (to a maximum of 68°) between early May and mid-August. The sun's position can be used to guide placement and selection of riparian plantings in relation to the stream system, in order to optimize the beneficial effects of shading.

4.2.3 WILDLIFE ISSUES

Overall biotic condition is reflected in the condition, health, and viability of populations of all native species within the watershed. Characterizing and/or monitoring all species is not possible from a practical standpoint, however. We therefore focus our attention on species, such as salmonid fish, whose presence or absence indicates the health of the ecosystem, on "special status" species, such as threatened and endangered species, and on game species.

The populations of game species of wildlife within the watershed are probably relatively stable, with little recent change in the abundance of suitable habitat for deer, elk, and waterfowl. There is some concern regarding potential damage to farm and rural residential properties from large herds of elk, which are common in the watershed. Planned aggressive treatment for SNC is expected to greatly increase foraging habitat and decrease cover for big game animals.

Special status terrestrial species in the Trask River watershed include the northern spotted owl, marbled murrelet, bald eagle, red tree vole, white-footed vole, several species of bat, and assorted other wildlife species afforded special status by the state or BLM. Most special status terrestrial wildlife species in the watershed are at least partially dependent on late-successional coniferous forest and/or associated large trees or snags. Such habitat is currently rare within the watershed, and is found primarily along the northern edge of the Upper Trask River subwatershed, primarily on BLM land. Forest management focused on the protection of existing late-successional forest and the future production of additional late-successional forest would be expected to benefit most of these species over the long term. In addition, management of younger stands to more quickly develop late-successional characteristics, such as tree size and age diversity, snags, down logs, variable density, and species diversity, would also be expected to benefit some special status species in the shorter term.

4.2.4 VEGETATION ISSUES

Vegetation patterns have changed dramatically from reference conditions. In the uplands, extensive late-successional mixed conifer forests, interspersed with early- to mid-successional forests and openings created by natural disturbance, have largely been replaced by much more homogeneous young forests of Douglas-fir (with hemlock in some areas) and extensive stands of red alder in riparian and disturbed areas. Botkin et al. (1995) estimated that the Coast Range forest historically consisted of a mix of stand ages and types, in which about half of the forest, on average, was older than 200 years, and the remaining half was distributed across the range of 0-200 year-old stands. In lowland areas, the former mix of forests, wetlands, and prairies has largely been replaced by agricultural land, with some urban and rural residential developments. There are few pockets of uneven-aged, multi-layered, mixed-species conifer stands remaining in the watershed. Important vegetation issues include:

- scarcity of late-successional forest,
- species and age-class homogeneity of riparian forest,
- prevalence of closed-canopy, even-aged Douglas-fir stands,

- management of Swiss needle cast and other forest pathogens.

4.2.4.1 Potential Habitat Management Strategies

A certain minimum amount of intact habitat is required to maintain population viability of native species within the landscape. For example, populations are unlikely to persist where patches of intact habitat are smaller than the home range of the species. In addition to habitat area, the spatial pattern in habitat availability is also important. Both natural processes (e.g., fire, windthrow) and anthropogenic activities (urbanization, agricultural development, silviculture) have influenced the size and distribution of habitat patches within the Trask River watershed. The interactions between natural disturbance and disturbance due to management practices largely determined the risk of species loss. Species that became isolated as a result of fragmentation and were also restricted to specific habitat types have tended to be most vulnerable to extirpation (Young and Sanzone 2002).

Fractal dimension, or the perimeter-to-area ratio of habitat patches, provides an index of patch complexity (O'Neill et al. 1988). Natural areas impacted by natural disturbance regimes tend to have more complex shape and, therefore, a higher fractal value than patches caused by management actions (Krummel et al. 1987, Young and Sanzone 2002). Distance between adjacent patches can influence dispersal ability, or the extent to which species can move between patches, although the quality of intervening habitat can also be critical.

Natural disturbances generally do not produce extensive areas of uniform impact (Turner et al. 1998), but rather create complex patterns of heterogeneous landscape in which disturbance effects range from severe to none. Even very large fires typically leave some stands unburned due to wind shifts and natural fire breaks (Turner and Romme 1994, Young and Sanzone 2002). The mosaic of habitat created by differential disturbance has important influences on biotic structure, diversity, and ecosystem function. These influences are important for vegetation development and for developing appropriate management guidelines (Young and Sanzone 2002). The impacts of natural disturbance are modified by the frequency, intensity, extent, and duration of the disturbance events. Such factors are important regardless of the type of disturbance, for example, fire, flood event, or insect infestation.

Currently, large and very large conifer forests are rare in the watershed. Based on CLAMS data, medium (10-20 inches dbh) conifer stands are most prevalent in the Middle Fork of the North Fork (56%), Elkhorn Creek (40%), East Fork of the South Fork (37%), North Fork of the Trask (30%), and North Fork of the North Fork (28%) subwatersheds (Table 3.25). These areas offer good opportunity for thinning prescriptions aimed at early development of late-successional characteristics in younger stands.

The ODF management strategy, structure-based management, strives to achieve an array of forest stand structures in a functional arrangement that more closely emulates historical variability and diversity, while also providing social and economic benefits. Five stand types are defined for management purposes: regeneration, closed single canopy, understory, layered, and old forest structure. The desired future distribution of each stand type is specified in the

Implementation Plan (IP) for each district. (For more information on structure based management, including descriptions of each stand type, please refer to the FMP.)

The Tillamook District IP specifies a desired future condition of 20% Older Forest Structure. The portion of the watershed most amenable to the development of larger blocks of late-successional forest includes the extensive ODF and BLM holdings in the middle section of the watershed. Many special status species might thrive best in larger blocks of late-successional habitat than will be provided by riparian areas in the future.

Consequently, prospects may be better for species that thrive in smaller patches of late-successional forest and for species that depend on elements of late successional forest that can be cultivated in smaller blocks of younger forest. Suitable habitat for such species can probably best be created and maintained along riparian corridors, such as in Riparian Management Areas on ODF lands and Riparian Reserves on BLM lands. Partnership opportunities might also be possible with private land owners. It is likely that federal, state, and private lands will all continue to provide an abundance of habitat for species that are dependent on early- and mid-successional forest habitats and on edge habitats. It is also likely that such lands will continue to provide an abundance of riparian alder habitat, even as some of those areas are converted to conifer.

Hardwood stands are most prevalent in the South Fork Trask and Upper Trask subwatersheds (Table 3.25). These areas present good opportunities for increasing conifers in patches along the stream. Management should strive to increase riparian habitat heterogeneity in such areas, while enhancing LWD recruitment potential and (where necessary) stream shading.

The Oregon Forest Practices Rules specify an alternative vegetation prescription for sites that are "capable of growing conifers, and where conifer stocking is currently low and unlikely to improve in a timely manner because of competition from hardwoods and brush". The alternative prescription is intended to provide adequate stream shade, some woody debris, and bank stability for the future while creating conditions in the streamside area that will result in quick establishment of a conifer stand. Up to half of the stream length can be included within conversion blocks, not more than 500 ft long and separated from each other by at least 200 ft of retention block.

4.2.4.2 Noxious and Exotic Plants

Noxious and exotic plants will continue to exist in the Trask watershed. This problem is, and will continue to be, most pronounced in roadside and other disturbed areas. Many of the exotic plants in the Trask require high amounts of sunlight to grow rapidly and reproduce. While these plants are a concern, particularly in reforestation efforts, they are not considered to be a long-term threat to the integrity of the forest ecosystem, because they quickly disappear when overtopped by other vegetation. Examples of exotic plants which fall into this category include Scotch broom, Himalayan blackberry, giant knotweed, Canada thistle, and bull thistle. There are currently no known populations of English ivy or holly in the forested areas of the Trask watershed. English ivy and holly can pose a serious threat to the forest community because they are able to grow and reproduce in shaded conditions. Tansy ragwort can be expected to continue to be a problem in lowland areas, and reed canary-grass in wetlands.

Every effort should be made to curtail the spread of noxious and exotic plants, and eradicate isolated patches of noxious weeds, before they become unmanageable. Soil-disturbing activities that result in removal of the forest canopy favor the spread of these plants. Management actions could include limiting vehicular access to areas that do not currently have noxious and exotic weed problems, and cleaning large machinery of weed seeds and propagules to prevent unintentional dispersal of the plants. Such preventative actions would likely be more successful than attempted treatments subsequent to an invasion by a particular invasive species. The BLM strategy for preventing and controlling the spread of noxious weeds on BLM land is described in the document "Partners Against Weeds. An Action Plan for the Bureau of Land Management" (www.blm.gov/education/weed/paws). It lists goals and associated actions necessary for implementing an improved weed management program. They include elements of prevention, detection, education, inventory, planning, coordination, monitoring, evaluation, research, and technology transfer.

It is likely that active forest management on ODF lands in the Trask River watershed will increase in the coming decades. Such activities can potentially increase the likelihood of spreading noxious weeds within the watershed. Thus, it is important to have policies in place to curtail the spread of noxious and invasive plants. The FMP emphasizes integrated pest management principles and cooperation between landowners to address issues related to invasive plants.

4.2.4.3 Factors Affecting the Distribution of Protected Plant Species

Continued expansion of noxious and exotic weed species, especially in disturbed environments, could have adverse impacts on sensitive plants. Because habitat loss for rare plants, and other species of concern, is an important factor considered by ODF and BLM management, preservation of relatively high-quality habitat is of increased importance on state and federal lands. ODF and BLM actively manage for rare and special status plant species. None of the Threatened, Endangered, Candidate, or Special Concern plant species that are known to occur in the Trask River watershed (Table 3.27) are restricted to late-successional forest.

4.2.5 FOREST RESOURCES ISSUES

4.2.5.1 Timber Harvesting

Timber operations within the watershed are expected to produce substantially more wood in both the near and the long term, as compared with the past half century. Since completion of salvage logging subsequent to the Tillamook Burn fires, much of the watershed has been in the process of forest revegetation and regrowth to harvestable age. Opportunities for increased logging will develop in the near future and the pace of logging will probably increase dramatically because of

SNC infection. It is expected that the Trask watershed will soon become an important supplier of timber, from both private and public lands.

Increased timber harvest will be accompanied by increased potential for conflicts with other beneficial uses. Past logging and fire caused substantial erosion, sedimentation, and stream channel problems throughout the watershed, and adversely impacted fisheries resources. Such impacts should be substantially lessened with renewed logging because of improved forestry practices. However, some degree of future adverse impact should be expected. Because lands within the watershed are deficient in late-successional habitat, future management plans should give high priority to protection of existing late-successional forest and promotion of late-successional characteristics in some areas through commercial thinning prescriptions in selected second-growth areas. Because of differing objectives and management practices on private and public lands, the greatest opportunities for protection and enhancement of sensitive habitats will be found on public lands.

4.2.5.2 Management of Snags and Down Wood

The abundance of snags, especially in the more recent decay classes, has been greatly reduced throughout the watershed compared with reference conditions. Due to the lack of mature and late-successional forest, future down wood recruitment potential is limited and will remain so for many decades. Such potential is likely to increase more on public than private lands, except in narrow strips along streams. Leave-tree requirements and creative thinning procedures are expected to gradually increase the supply of large trees (and therefore snags and down wood) over time, especially on federal and state lands. Further active management efforts to increase the abundance of snags and down wood would improve conditions in the short term, and would be expected to benefit a variety of wildlife species, including cavity-nesting birds, bats, and flying squirrels.

Placement of fresh, down Douglas-fir trees can impact the remaining stand via Douglas-fir beetle infestation. USFS entomologists estimated that the number of standing trees killed by beetles following wood placement would be about 25% to 60% of the number of fresh down Douglas-fir trees added to the forest floor (Hawksworth 1999). Trees stressed by root rot are particularly susceptible to beetle mortality. Such mortality should be anticipated, but can further add to snag formation and thereby enhance the diversity of stand structure.

Douglas-fir beetles are attracted to freshly cut logs, and can produce significant amounts of brood in trees which are 12 inches dbh and larger. The threshold for the number of down trees necessary for beetles to produce enough brood to attack and kill additional standing green trees is three per acre. As the diameters of these trees and the numbers of trees increase, so does potential for producing more beetles. This, in turn, increases the risk of additional Douglas-fir mortality in the surrounding area. The rule-of-thumb based on observations in Westside forests is that after blowdown events, about 60 additional trees will be attacked and killed over the subsequent three years for every 100 down trees. It should be noted that generally these observations were in larger, older trees (much larger than 12 inches dbh) in older stands (over 100 years).

Several actions may be taken to reduce the risk of unacceptable amounts of additional beetle-caused mortality, with greater risk being more acceptable in the late-successional reserve LUA than in other management units. Following are recommendations to consider when writing silvicultural prescriptions to fell green Douglas-fir trees for decay class one LWD inputs:

1. When felling trees which are 12 inches dbh or larger, cut the minimum number of trees possible that will allow achievement of the LWD objectives.
2. Fell the trees in areas that are more likely to receive direct sunlight. Studies have shown that beetles produce less brood in logs with less shading.
3. Avoid felling trees in areas where standing live Douglas-fir trees are known to have reduced vigor and where it would be unacceptable for many of these trees to die.
4. Fell groups of trees in separate events that are spaced three to five years apart. Five-year intervals would minimize the risk of the local beetle population building to an unacceptable level.
5. If possible, felling should occur from about August 1 to October 1. This will allow some drying of the cambium before the spring beetle flight, and may lessen beetle brood production. If subsequent beetle-caused mortality is not a particular concern, such as in a late-successional reserve area, timing of tree felling may not be an issue.
6. Postpone felling of LWD trees if bark beetle populations are known to be high, or if there has been considerable amounts of tree mortality in the general area for the previous year or two (based on the Insect Aerial Detection Survey maps available from USDA Forest Service, Forest Health Protection).
7. Fell species other than Douglas-fir for LWD recruitment.

The risk of bark beetle population buildup is less in healthy, young stands than on older, less vigorous stands. The risk of additional tree mortality in a stand 40 years old (common to BLM land in this watershed) or younger is probably very low. This risk probably increases through time, with stands 80 to 100 years old becoming more susceptible to some overstory mortality. Remnant old-growth pockets, in particular, would be at risk of some tree mortality if beetle populations increased significantly in those areas because of LWD creation.

4.2.5.3 Management of Laminated Root Rot, Swiss Needle Cast and Other Forest Health Concerns

Phellinus weirii root rot is likely to cause more extensive damage in managed stands as compared with natural or late-successional stands. Most of the Trask watershed is currently forested with Douglas-fir, which is highly susceptible to root rot mortality. Disease centers become apparent in stands older than about 15 years. Volume production in disease centers can be expected to be less than half that of healthy stands (Thies and Sturrock 1995).

When conducting commercial thinning operations, high levels of root rot infestation are of special concern. Thies and Sturrock (1995) recommended avoiding commercial thinning in stands of Douglas-fir when the disease is present in 20% or more of the stand.

Forest management decisions in the near future are likely to be heavily influenced by the prevalence and spread of SNC, which currently infects a substantial component of the South Fork Trask River and its tributary subwatersheds. Swiss needle cast threatens forest productivity, but is not a major cause of tree mortality. Recommended management options include thinning in low- to moderately-infected stands, and clearcutting severely infected areas. Recent studies have indicated that trees respond positively to thinning, but the degree of response declines with increasing SNC severity (Maguire et al. 2003). Management decisions to counteract the spread of Swiss needle cast may seriously conflict with other forest management goals. Careful monitoring will be important to determine the extent to which the planned clearcutting contributes to higher stream temperature and/or sediment loads.

Swiss needle cast damage was assessed by the Swiss Needle Cast Cooperative (SNCC) in 1997 through 2002 (SNCC 2002). Monitoring was conducted during April and May in 77, randomly-selected Douglas-fir plantations in the northern Coast Range, selected to be representative of all Douglas-fir plantations between 10 and 30 years old (in 1996) and located within 18 miles of the coast, within the zone of greatest SNC damage. Mean needle retention for all plots showed little evidence of change in the degree of damage since 1997. There was a slight, but statistically significant, increase in mean needle retention from 2001 to 2002.

Many of the stands that are moderately to severely impacted by SNC are pure Douglas-fir stands that resulted from reforestation of the Tillamook Burn. According to the Tillamook District IP, management will aggressively treat SNC, consistent with OSU model run 1C-2. This model run calls for harvesting of severely impacted stands (i.e., those with less than two years of needle retention) within the first two decades if they are more than 20 years old. Other management recommendations include the encouragement of non-Douglas-fir species; thinning is not recommended in stands having high damage (Filip et al. 2000).

4.2.5.4 Management of Hardwood Stands

A substantial portion of the watershed, and much of the riparian zone, contains hardwood or mixed hardwood/conifer stands. Red alder is particularly abundant, especially in riparian areas and along roads and other disturbed sites. Red alder was probably always abundant in riparian corridors along the Trask River and its tributaries, but its abundance may have increased substantially since Euro-American settlement. Many of these sites formerly supported (in addition to red alder) western red cedar, hemlock, and other conifers, including Sitka spruce in the lower watershed. In some places, conifers can be actively reestablished; other places are either too wet to support conifers or are not amenable to conifer establishment at the present time because of previous soil disturbance.

It would not be desirable, or perhaps even possible, to remove most of the alder from the riparian zone. Alder leaves constitute an important allochthonous nutrient and food source to the aquatic ecosystem. Nevertheless, the scarcity or absence of other species and age classes in the riparian forest of the Trask watershed is noteworthy when compared with our understanding of reference conditions, although we don't know the abundance of riparian alder in the historic forest. In addition, the prevalence of alder outside the riparian zone may represent a substantial reduction in expected timber volume production. The difference in volume production between alder and conifer stands will become larger over time, as the conifer forests mature.

Releasing conifers, as well as planting conifers in small patch cuts in selected riparian areas, can be an effective management strategy to restore the balance between riparian hardwoods and conifers. Anticipated benefits would include increased stream shading, LWD recruitment potential, stand diversity (species, layers), and habitat suitability for a variety of special status species. In addition, alder removal from some riparian areas would likely cause a decrease in the transport of nitrogen, which contributes to estuarine eutrophication, from the forest to Tillamook Bay. Small-scale efforts to create openings in the alder stands for conifer release (with or without conifer planting) could be considered for implementation as a long-term, ongoing effort.

4.3 SOCIAL

4.3.1 AGRICULTURE

Agricultural production represents an important part of the Trask River watershed economy. Agricultural activities also impact watershed resources and create conflicts with other beneficial uses. Fecal bacteria contamination of streamwater, bank erosion, stream heating, water use, eutrophication, wetlands degradation, stream channel simplification, and blockage of fish passage are all associated with agricultural activities. Such operations create potential conflicts with salmonid fishery, shellfish, and recreational resource utilization. With improved management practices, negative impacts and conflicts can be, and in some cases are being, reduced. For example, there is evidence that fecal coliform bacteria concentrations in the Trask River, which are partially derived from agricultural activities, have decreased in recent decades (Figure 3.17), although concentrations still often exceed health criteria.

Many organizations have been actively involved in implementation of improved farm management and such actions as riparian fencing, culvert replacement, wetlands enhancement, and riparian planting. Active participants have included the Farm Service Agency, Natural Resources Conservation Service, Tillamook County Soil and Water Conservation District, Tillamook Bay National Estuary Project, Tillamook Estuaries Partnership, Tillamook County Creamery Association, Oregon Department of Agriculture, OSU Extension Service, Oregon Department of Environmental Quality, and Tillamook Bay Watershed Council.

4.3.2 RURAL RESIDENTIAL AND URBAN USES

Increases in the human population can be expected to continue in the watershed, with such increases mainly concentrated in urban and rural residential areas in the lower watershed. With population growth, demands will increase on space and natural resources, including increased water use, wastewater generation, and recreational fisheries. As the human population increases, especially the retirement population, additional conflicts between agricultural and urban interests can be anticipated. Increased rural residential development will be accompanied by added pressure on water resources. In addition, either wastewater treatment capabilities will have to be increased or the number of septic systems (and the potential for water quality degradation) will increase.

Urban and rural residential land uses constitute important sources of fecal bacteria to the lower Trask River (Sullivan et al. 1998b, 2003) and also contribute to other aspects of water quality degradation. Such problems are likely to increase in the future, with population growth, unless actions are taken to lessen the adverse impacts associated with storm drains, sewage treatment plants, industrial effluents, septic systems, and animal husbandry. Opportunities for creative partnership among ODF, BLM, and urban and rural residential communities should be explored. The Tillamook Estuaries Partnership may be an important vehicle for fostering such interactions.

4.3.3 RECREATION

Recreational opportunities are dispersed throughout the watershed, and throughout Tillamook Bay, which is influenced by water quality in the Trask River. Recreational fishing for salmonids is very popular throughout the watershed, especially in the Lower Trask subwatershed. Hunting (mainly for elk, deer, and waterfowl) is popular on public and private lands. Hiking, biking, horseback riding, kayaking, wildlife viewing, and off-road vehicle use also take place on public lands watershed-wide. Impacts on natural resources from recreational activities in the watershed are probably generally minimal. However, there is likely some increase in erosion from road and trail surfaces due to vehicular and foot traffic and increased risk of spreading of noxious plants.

4.3.4 CULTURAL RESOURCES

Because Native American tribes utilized the lower watershed extensively prior to Euro-American settlement, there is a high probability that cultural resources exist in many places within the lower watershed. However, Native American utilization of the upper watershed, where most ODF and BLM land is located, was sporadic. BLM is exempt from rules requiring pre-disturbance surveys because of the low probability of encountering cultural resources.

4.4 SUBWATERSHED RANKING

A ranking system was devised to enable comparison among subwatersheds of conditions on ODF and BLM lands regarding seven indicators of aquatic and riparian habitat condition. Results of that ranking are shown in Table 4.13. The ranking on ODF lands probably reflects conditions throughout most of the upper watershed. Overall, Elkhorn Creek and the East Fork of

Table 4.13. Ranking of subwatersheds on ODF and BLM lands based on 7 indicators of aquatic and riparian condition. Each indicator was ranked in ascending order according to the desirability of the condition, (e.g. the highest pool frequency was ranked 1, etc.). The rankings for all indicators were summed to create the rank score. The lowest rank score represents the watershed with the most desirable combination of the 7 indicators. Overall rank lists the rank scores in ascending order based on the desirability of conditions.

ODF Land	Subwatershed Area (sq mi)	Total Road Length in Subwatershed (mi)		Overall Rank	Sum of the Ranks of the 7 Indicators	Road / Stream Crossing Density	Road / Stream Crossing Rank	Roads on Hillslopes >50% (mi of road)	Roads on Hillslope >50% Rank	Stream Shade (% High Shade - from Falcy)	Stream Shade Rank	Conifer LWD Recruitment Potential	Conifer LWD Recruitment Potential Rank	Average of Pool Frequency	Average of Pool Frequency Rank	Average Density of LWD in Stream	Average Density of LWD in Stream Rank	Average of % Gravel in Riffles	Average of % Gravel in Riffles Rank
Elkhorn	8.4	35.6		1	12	10.4	5	3.5	3	98	2	29	2	9	3	17.3	1	52	1
EF of SF of Trask	25.5	87.9		2	17	6.9	3	3.9	5	98	1	17	4	50	1	14.0	3	41	3
MF of NF of Trask	6.0	18.9		3	24	11.4	6	0.5	1	95	4	31	1	6	6	0.0	6	27	6
NF Trask	23.5	70.1		4	25	8.2	4	6.6	7	97	3	6	6	6	5	14.1	2	34	2
SF Trask	18.4	49.4		5	26	6.8	2	5.5	6	93	5	9	5	13	2	13.9	4	37	4
Upper Trask	13.7	39.0		6	32	6.5	1	3.6	4	86	7	4	7	8	4	0.3	5	16	5
NF of NF of Trask	5.4	22.5		7	32	13.0	7	3.2	2	87	6	17	3	5	7	0.0	7	24	7

BLM	Subwatershed Area (sq mi)	Total Road Length in Subwatershed (mi)		Overall Rank	Sum of the Ranks of the 7 Indicators	Road / Stream Crossing Density	Road / Stream Crossing Rank	Roads on Hillslopes >50% (mi of road)	Roads on Hillslope >50% Rank	Average Stream Shade (from ODFW)	Average Shade Rank	Total # of Conifers in Riparian Zone	Total # of Conifers in Riparian Zone Rank	Average of Pool Frequency	Average of Pool Frequency Rank	Average Density of LWD in Stream	Average Density of LWD in Stream Rank	Average of % Gravel in Riffles	Average of % Gravel in Riffles Rank
Elkhorn	3.83	13.4		1	18	12.3	5	1.75	5	91	2	349	2	9.62	1	13.3	2	49.5	1
SF Trask	0.78	3.1		2	19	10.2	4	0.3	3	100	1	0	4	5.5	3	21.9	1	32	3
Upper Trask	3.56	2.0		3	20	0.3	1	0.11	2	63.3	5	679	1	6.67	2	1.1	4	11	5
NF Trask	3.05	3.7		4	23	3.9	2	0.82	4	67.7	4	33	3	4.53	5	2.6	3	34.8	2
MF of NF of Trask	2.0	3.7		5	25	4.1	3	0.03	1	76	3	0	5	5.5	4	0.0	5	17	4

the South Fork subwatersheds were highest quality and the North of the North Fork and Upper Trask subwatersheds were lowest quality. (The Lower Trask subwatershed does not include ODF or BLM ownership.) On BLM land, the overall conditions in the Upper Trask, South Fork Trask, and Elkhorn Creek were generally better than conditions on BLM land in the North Fork Trask and Middle Fork of the North Fork subwatersheds.

4.5 DATA GAPS AND FUTURE ACTIONS

4.5.1 DATA GAPS

A number of data gaps were identified in the process of conducting this assessment. In the following section, we describe each data gap, explain its significance, and list steps that could be taken to fill the data gap. However, often it was impractical to estimate the specific amount of time or energy required to fill a particular data gap because of the many potential variables involved. These could include the priority given to the task, the number of staff available, and the spatial extent of the data gathering effort. In many cases, conducting an initial pilot study may be advisable.

Erosion and Sediment

- *Data regarding natural landslide and debris flow occurrence.* The locations of recent landslides, scoured channels, and debris flow fans on mainstem streams are mostly undocumented. A record of the frequency and distribution of natural landslides and debris flows would help to better understand the spatial and temporal erosion regime. The most effective method of identifying landslides and debris flows is on-the-ground inventory following a large storm event (e.g. 30 to 50-year storm), although this requires considerable time and effort. Air photo-based inventories have been used frequently in the past, and are more cost-effective, but often fail to detect landslides and debris flows under dense forest canopy and in old-growth.
- *Data regarding landslides and debris flows originating from harvest units and roads*. Virtually no information exists for landslides in harvest units in the Trask watershed, although the locations of road fill that is sinking, cracking or sliding were recorded in the recent road inventory. Information regarding the frequency, distribution, and characteristics of management-related landslides and debris flows would help to better determine the magnitude of management-related sediment contribution, the management practices most commonly associated with increased sediment levels, and the areas of greatest concern. Data could be collected as part of an inventory of natural landslide and debris flow occurrence, as described above, in addition to the data that are gathered in the road inventory. The road inventory could also be expanded to include both natural and management-related landslides and debris flows, although such an approach would only account for events that are observable from the road network.

- *Likely future debris flow locations, for LWD recruitment.* Information regarding potential source areas of debris flows, with a focus on locations that have a high probability of delivering LWD to important mainstem stream channels, would be useful in prioritizing upland areas for the accelerated development of large trees and older forest structure. Such an analysis would probably require a combination of GIS analysis and field verification of bedrock geology, soils, slope steepness, tributary stream lengths, and tributary junction angles in relation to important mainstem stream reaches.

Stream Channel

- *Field verification and further update of the channel habitat type data layer.* This would be useful if it is expected that channel habitat types will be used as a management tool in the future. Channel habitat types provide a categorization of physical stream characteristics that can help identify locations where high-quality habitat has the potential to occur, indicating where in-stream restoration will be the most effective. Verification of the CHT layer would require a moderate field effort, in addition to updating the GIS coverage.

Water Quality

- *Additional stream temperature data along the mainstem and upper tributaries.* This would be useful to document the spatial and temporal extent of temperature exceedences above the salmonid migration criterion. A well-designed study of stream temperature would help determine the spatial and temporal extent of high temperatures in the watershed. In particular, unresolved questions regarding upstream-downstream temperature changes, tributary vs. mainstem temperatures, and the relationship between shade and temperature in the Trask watershed could be addressed. Gathering the required temperature data would involve placing about 50 stream temperature monitoring devices in carefully chosen locations throughout stream network for one or two summers, and analyzing the resulting data.
- *The location and condition of septic systems on private in-holdings along the mainstem and lower tributary streams of the Trask River.* Leaking septic systems present an important source of fecal coliform bacteria to the lower river and the bay. This project would require cooperation with private landowners to identify locations where septic systems may be leaking. Such an effort would require contacting landowners and perhaps on-site evaluations. This task could be recommended to the Department of Environmental Quality, the Tillamook Estuaries Partnership, or the watershed council.
- *Data regarding fine-scale changes in stream shade and water temperature.* Improved information of fine-scale changes in stream shade and water temperature would help pinpoint locations where stream temperature increases substantially, facilitating prioritization of areas for riparian restoration. Existing riparian shade data, including GIS coverages of shade as well as aerial photos,

could be analyzed for high shade zones along mainstem streams, and verified during visits to the field.

Aquatic Species and Habitats

- *Locations of fish passage barriers (in particular, culverts).* Identification and removal of fish passage barriers would provide access to fish of upstream areas, potentially increasing the amount of available habitat. Fish passage barrier removal is one of the most effective means of improving conditions for fish populations. Field inventories of potential barriers, such as culverts, would be required. Both ODF and BLM have inventoried some culverts on their lands, but many potential barriers have not been assessed for fish passage.
- *Amphibian distribution, especially of sensitive species.* While some species of amphibians may have habitat requirements that are similar to salmonids, others may not. Protecting salmonid habitat may not guarantee that amphibian habitat is available, especially for species that use non-fish bearing streams. Surveys for amphibian distribution and habitat use would help determine if amphibian habitat requirements are being met. A field survey with a focus on small streams would be required, in conjunction with GIS data development.
- *Aquatic macroinvertebrate distribution.* The species composition and distribution of macroinvertebrate communities is very useful for assessing water quality and determining habitat conditions for fish and other species. Macroinvertebrate surveys could be conducted by volunteer field crews, under the supervision of a trained technician. The watershed council may be a good partner for a macroinvertebrate study or monitoring program.
- *Locations of small wetlands in the upland, forested zone of the watershed.* Knowledge of the locations of both existing and historical wetlands and flooded off-channel areas in the uplands would be useful, since wetlands frequently provide rearing habitat for juvenile fish. An analysis of likely locations could begin with an examination of soil maps and topographic maps or digital elevation models (DEMs), followed by visits to the field.
- *Population status and distribution of special aquatic species.* State and federal agencies have a variety of classifications for species warranting special attention. However, with the exception of federally listed Threatened and Endangered (T&E) species, little information exists regarding the condition and distribution of most of these species in the Trask watershed. Often, the difficulty in studying these species is viewed as prohibitively costly, in terms of time and effort. Frequently, it is assumed that if habitat conditions for the species are suitable, then the population is probably sufficiently healthy. However, whenever possible, gathering information on these species is advisable, especially if active intervention can result in stabilizing a population. Sponsoring university graduate students and partnering with fish and wildlife agencies are often the most cost-effective methods of increasing the level of knowledge of a special species.

Wildlife Species and Habitats

- *Distribution and/or presence of special wildlife species.* Like special aquatic species mentioned above, very little information exists regarding the condition or distribution of most non-aquatic species that have been identified as warranting special attention by public agencies, with the exception of the northern spotted owl and marbled murrelet. For more discussion of this topic, see *special aquatic species*, above.

Vegetation

- *Information regarding distribution and trends of establishment for noxious and exotic weed species.* While noxious and exotic weeds do not yet constitute a severe problem in the Trask watershed, often the best opportunity to control them is when the population is still small. Consequently, it is advisable to monitor the status of noxious and exotic weeds in the watershed. The development of a system that allows analysis and characterization of the status of noxious and exotic weeds would be useful. Information regarding the location of weeds could be gathered in the field during routine weed eradication efforts, and the information could be analyzed on a periodic basis to determine trends and spatial patterns of noxious weed populations in the watershed.
- *Locations of large conifers in riparian zones.* Knowledge of the locations of existing large conifers would help to prioritize areas where additional action to improve conifer presence in the riparian zone is warranted. Existing aerial photo-derived information could be used to select riparian forest areas for field surveys. Locations could be mapped using GIS. In low-priority areas, the GIS layer could be updated on an ad-hoc basis, whenever a previously unknown large conifer is identified.
- *Candidate locations for enhancing the prevalence of conifers in hardwood stands.* Encouraging the growth of conifers in the riparian zone would help to accelerate the process of maintaining a steady supply of high-quality LWD to the stream channel, as well as providing shade to moderate stream temperature. Identification of candidate locations for LWD enhancement would require a prioritization of riparian zones based on existing shade, salmonid use, and stream geomorphology or CHT, followed by targeted field surveys.

Roads

- *Location of legacy roads.* In particular, information regarding the location of legacy roads that have the potential to contribute sediment to streams in future large storm events would be useful. The amount of effort required for this task would depend largely on the extent to which this information could be gleaned from archived maps. Where no such maps exist, it would require a significant effort to identify and map legacy roads.

- *Detailed road and culvert condition information, including mapped locations of problem culverts and road segments.* Detailed road and culvert information would help to prioritize actions to reduce erosion and sediment contribution to the stream system. ODF's Road Information System has provisions for the gathering of these data, although the road inventory was not complete at the time of this report. On BLM lands, road information has been gathered for the Elkhorn Creek APU, although data from other areas are absent.

Recreation

- *Locations of OHV damage areas, and areas in need of repair or closure to OHV use.* Knowledge of the locations of OHV-related damage would help to assess the extent of impact by OHV use. This information could be gathered in the field, and then mapped using GIS. While staff members may already have personal knowledge of this information, development of a GIS layer would be desirable. On ODF lands, implementation of the Tillamook State Forest Recreation Action Plan should address this data gap.
- *Information regarding the amount of OHV use, and the impact of OHVs on the forest.* Together with knowledge of the locations of OHV damage areas, as mentioned above, information regarding the amount and severity of impact would make it possible to define management policies that keep damage of the forest to a minimum, and ensure that erosion is prevented. On ODF lands, implementation of the Tillamook State Forest Recreation Action Plan should fill this data gap. The development of a monitoring system in accordance with the Recreation Action Plan that facilitates analysis and query of collected information, in addition to spatial analysis using GIS, would be desirable.

4.5.2 FUTURE ACTIONS

Specific recommendations are provided in Chapters 5 and 6 with respect to actions and/or management decisions by ODF or BLM, and these actions and decisions can, in fact, improve watershed health and increase the amount and quality of aquatic, riparian, wetland, and forest habitat within the watershed. Some issues, however, do not lend themselves very well to unilateral actions on the part of a single ownership category. For example, stream temperatures in the lower watershed are likely to remain above standards for salmonid migration, irrespective of the actions taken by ODF and/or BLM. Similarly, high concentrations of fecal bacteria and low dissolved oxygen concentrations in the Lower Trask subwatershed are not likely to be influenced at all by federal or state land management within the watershed. The temperature and dissolved oxygen water quality problems, which are most pronounced downstream from ODF and BLM land holdings, adversely impact anadramous salmonids that utilize streams on public lands during parts of their life cycle. Only through cooperation that includes private landowners can such problems be effectively addressed.

Among the most important management actions that can be taken by the BLM and ODF to improve water quality and salmonid habitat in the Trask River watershed is the establishment of conifers, and ultimately large conifers, in the riparian zone. This can be accomplished by planting and/or releasing a diversity of conifer species, including western hemlock, western red cedar, Douglas-fir, and (in lowland areas) Sitka spruce along all stream segments that are currently deficient in such plantings. Priority should be given to areas in and around core salmonid spawning and rearing habitat, tributary systems that currently experience excessively high stream temperatures and/or high streambank erosion, and important salmonid migration corridors. The goals of this effort should include enhancement of stream shading, lowering of stream temperatures, stabilization of streambanks, improvement of LWD recruitment potential, reduction of erosion, and ultimately increase in the number and depth of pools. An additional benefit to the terrestrial component of the watershed would be the establishment of (mostly narrow) riparian corridors that exhibit late successional characteristics and the creation of suitable habitat for some Special Status plant and animal species that are dependent upon such habitat characteristics.

In some areas, this planting effort should involve encouraging the establishment and dominance of conifers in riparian areas that are currently alder-dominated. Girdling and felling of alder trees could complement interplanting with conifers to help facilitate conifer release. Care should be taken, however, to not remove alder too aggressively prior to establishment of conifer shading, so as to not temporarily worsen the stream temperature problem. The gradual replacement of alder with conifers in some areas will have the added benefit of reducing nitrogen levels in streamwater, a contributor to eutrophication of Tillamook Bay.

It must be recognized that the benefits of these riparian planting and conifer release efforts will not begin to be seen for several years, and will subsequently be manifested over a period of many decades or longer. Management actions taken now will realize benefits well into the 21st century and beyond.

In addition to actions focused on the establishment of riparian conifers, additional recommended actions to improve both water quality and salmonid health include identification and removal of fish passage barriers, replacement of inadequate culverts, repair or decommissioning of roads, and the restoration and reconnection of off-channel wetlands and other high-flow refugia. Such improvements will open access to otherwise suitable habitat, help restore lost rearing habitat, provide escape from peak flow conditions, improve water quality through filtration of pollutants and removal of fine sediments, and reduce erosion.

Erosion problems in the watershed can be addressed in some areas by the riparian planting efforts described above and especially by efforts to control sediment inputs from roads (both legacy and potential new roads). Emphasis should be placed on road repair and decommissioning in roaded areas that are in close proximity to the stream channel and on steep slopes.

To the extent that new roads are needed to support thinning and/or logging efforts, streamside locations and steep slopes should be avoided where possible. Road construction, road repair, and road decommissioning should be accompanied by planting with native species to minimize erosion and establish vegetation cover.

When portions of the watershed are to be newly opened or are subject to increased vehicular and foot traffic to support forest management efforts, a noxious weed control program should be prepared and implemented. BLM currently has a noxious weed eradication program. Noxious weed eradication is much more difficult and expensive than preventative measures.

The most important potential management action to promote the health and diversity of terrestrial ecosystems on forested portions of the Trask River watershed is the protection and development of late-successional forest habitat. Such habitat should be fostered, where possible, in large blocks rather than small patches. BLM and ODF each provide methods for addressing this need. BLM provides for development of late-successional reserves. ODF intends to use Structure Based Management to increase the amount of forest in Understory and Older Forest Structure classes within the watershed, as presented in the Forest Management Plan and Implementation Plans. Increased prevalence of late-successional forest habitat will benefit a large number of species that utilize such habitat for their prosperity or survival. This effort should be accompanied by thinning and interplanting actions intended to encourage the development of elements of late-successional character in forests of only moderate age. Such elements include increased tree species diversity, multi-layered canopy, variable tree spacing, down logs, and snags. To some extent, these kinds of actions can help to enhance the value of riparian buffers, but should not be done at the expense of shading potential. However, riparian buffers will provide, at best, narrow strips of high-quality forest habitat. Many species require much larger blocks of good habitat.